

# THE LABOR DEMAND AND LABOR SUPPLY CHANNELS OF MONETARY POLICY

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ABSTRACT. Monetary policy is conventionally understood to influence labor demand, with little effect on labor supply. We estimate the response of labor market flows to high-frequency changes in interest rates around FOMC announcements and Fed Chair speeches and find that, in contrast to the consensus view, a contractionary monetary policy shock leads to a significant increase in labor supply: workers reduce the rate at which they quit jobs to non-employment, while non-employed individuals increase their job-seeking behavior. Holding supply-driven labor market flows constant, the overall decline in employment from a contractionary monetary policy shock becomes twice as large.

## 1. INTRODUCTION

*“Policies to support labor supply are not the domain of the Fed: Our tools work principally on demand.”* –Federal Reserve Chairman Jerome Powell, November 30, 2022

Monetary policy is traditionally viewed as affecting labor demand and having little effect on labor supply, as reflected in the quote by Fed Chair Powell, above. This conventional wisdom is also embodied in the original Keynesian IS-LM framework, as discussed by Galí (2013), in statements by other monetary policymakers around the world, and in the New Keynesian literature, where the standard assumption of sticky wages in a neoclassical labor market precludes any significant quantitative role for labor supply to affect the response of employment to a monetary policy shock.<sup>1</sup>

In contrast to the consensus view, we offer new empirical evidence of a substantial labor supply response to monetary policy. We begin by identifying labor market flows (and components of flows) that are plausibly driven by labor supply considerations. For example, we classify flows from unemployment (U) to nonparticipation (N) and vice versa as supply-driven, given that such flows occur when an individual decides

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<sup>1</sup>Broer et al. (2020) and Auclert, Bardóczy and Rognlie (2021) offer detailed discussions of this property of the sticky-wage NK model. See also the discussion of the related literature below.

to stop or start searching actively for work. Similarly, we classify quits to non-employment as supply-driven, given that such separations are initiated by the worker.<sup>2</sup> One contribution of our paper is to provide new evidence that a large and procyclical component of flows between employment (E) and nonparticipation (N) is due to worker-initiated quits.

We then estimate the response of labor market flows to exogenous variation in monetary policy by extending a standard structural monetary policy vector autoregression (VAR) to include those flows. Following Stock and Watson (2012), Gertler and Karadi (2015), and others, we identify the effects of monetary policy on the economy and labor market activity using high-frequency changes in interest rate futures around FOMC announcements as an external instrument. Crucially, we also employ the recent methodology of Bauer and Swanson (2023b) to improve the relevance and exogeneity of our external instrument, in part by exploiting additional interest rate variation around Fed Chair speeches. We are thus able to obtain substantially more accurate estimates of the labor market flow responses to monetary policy shocks than are available in the existing literature.

Consistent with the consensus view described above, our VAR analysis shows that flows from E to U increase following a monetary policy tightening, and flows from U to E decrease, in line with a weakening economy and lower labor demand.<sup>3</sup> However, in contrast to the consensus view, we also show that flows from N to U significantly *increase* following the monetary policy tightening, and flows from U to N *decrease*, consistent with heightened job search from non-employment and an increase in labor supply.<sup>4</sup> We further identify an important reduction in quits from employment to non-participation. Intuitively, this labor supply response is consistent with an income effect, where households increase their labor supply in a weakening economy to maintain their consumption, as in the classic “added worker effect” literature of Lundberg (1985) and others.

To quantify the importance of the labor supply response to a monetary policy shock, we build upon the methods of Shimer (2012) and Elsby, Hobijn and Şahin (2015). For example, we construct hypothetical impulse responses of employment holding a candidate labor market flow constant at its steady-state value, allowing us to quantify the contribution of that flow to the total employment impulse response. Holding the response of supply-driven labor market flows fixed, the response of employment to a contractionary monetary policy shock would be roughly twice as large.

We also study heterogeneity in the labor market responses of lower- and higher-educated workers to a monetary policy shock, to understand how such responses might

<sup>2</sup>The designation of labor supply flows that we consider here is similar to that considered for separate applications elsewhere in the literature, e.g., Krusell et al. (2017) and Alves and Violante (2023).

<sup>3</sup>Throughout the paper we use the terminology “flows” and “transition probabilities” interchangeably.

<sup>4</sup>We find similar evidence of labor supply increases to a contractionary monetary policy shock on the intensive margin of job search: non-participants are more likely to report that they want to work, while unemployed individuals use more search methods to find a job.

reflect an income effect on labor supply. We find considerably more cyclical employment responses among lower-educated workers, primarily due to a more responsive layoff margin.<sup>5</sup> Recalling that lower-educated workers also typically hold fewer assets with which to smooth consumption, to the extent that an increase in labor supply from a contractionary monetary policy shock is due to an income effect (as hypothesized above), we should see a larger labor supply response from lower-educated workers. Our estimates confirm that this is the case: after a contractionary monetary policy shock, lower-educated workers increase their labor supply by substantially more than higher-educated workers.

Finally, we relate our results to the large literature on New Keynesian (NK) macroeconomic models. First, our finding of a sizeable labor supply effect on employment in response to a monetary policy shock contrasts sharply with standard sticky-wage NK models, which assume that labor is demand-determined and thus rule out any meaningful role for changes in labor supply to affect the employment response to shocks, as discussed by Broer et al. (2020). Second, although the NK literature increasingly emphasizes the importance of heterogeneity in consumption to account for monetary policy’s aggregate effects, those models typically abstract from heterogeneity in labor supply. In contrast, our findings suggest that heterogeneity in labor supply responses to monetary policy is quantitatively important. Third, we show that the essential features of our estimates can be understood within a simple labor market search framework with endogenous labor force participation and sticky wages à la Krusell et al. (2017). As we show, the responses of non-employed workers in the model to a contractionary monetary policy shock accommodates both a substitution effect—whereby a reduction in the job-finding rate moves workers from unemployment to nonparticipation—and an opposing income effect—whereby the increase in the marginal utility of consumption reduces the consumption-equivalent value of leisure and moves workers from nonparticipation to unemployment. To be consistent with our findings of heightened job-seeking among the non-employed after a contractionary monetary policy shock, the income effect must dominate.

After surveying the literature, the remainder of our paper proceeds as follows. In Section 2, we review the standard empirical measures of labor market stocks and flows, and we introduce our decompositions of EU and EN flows and our intensive margin measures of labor supply. We also describe our empirical VAR analysis, including high-frequency identification of monetary policy VARs. In Section 3, we report our baseline estimates of how labor market flows respond to a monetary policy shock. In Section 4, we compute the hypothetical impulse response functions when shutting down the response of various labor market flows. In Section 5, we develop a simple labor search model with an active participation margin that is consistent with the relationship between monetary policy shocks and labor market supply that we find in the data. Section 6 concludes and discusses directions for future research. An Appendix provides additional details about the data and robustness of our results.

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<sup>5</sup>See Broer, Kramer and Mitman (2021) and Faia et al. (2022) for complementary findings of heterogeneity by income in the responsiveness of E to U flows to a monetary shock.

*Related Literature.* Our paper is most closely related to the nascent literature studying the conditional responses of labor market flows to monetary policy shocks (e.g., White, 2018; Broer, Kramer and Mitman, 2021; Coglianesi, Olsson and Patterson, 2022; Faia, Kudlyak, Shabalina and Wiczer, 2022). We contribute to this literature in several ways. First, we correct for the “Fed Response to News” bias in high-frequency identification documented by Bauer and Swanson (2023a,b), and incorporate additional high-frequency monetary policy announcements, speeches by the Fed Chair, into our analysis. As a result, our high-frequency estimates should be less biased and substantially more precise than those of previous papers.

Second, in contrast to much of the existing literature, we document that flows from employment to unemployment (EU) are roughly as important as flows from unemployment to employment (UE) in driving the overall response of unemployment to a monetary policy shock. Our estimates here contrast with those of Shimer (2012), who concludes that UE flows are responsible for the majority of the unconditional business cycle variation in unemployment.<sup>6</sup>

Third, other authors conclude that the unconditional cyclical behavior of certain labor market flows can largely be understood as reflecting cyclical changes in the composition of workers across labor market states (e.g., Elsby, Hobijn and Şahin, 2015). Applying a similar methodology, we verify that our estimates for the response of labor market flows to monetary policy shocks are not driven by cyclical changes in the composition of the labor market, implying that the estimated response of labor market flows to monetary policy shocks can be used to understand variation in labor supply at the individual level.

Fourth, while job-to-job transitions fall at the beginning of recessions, our estimates show virtually no response of these same flows to a contractionary monetary policy shock. Thus, our findings fail to uncover clear evidence in support of the “offer-matching theory of inflation,” where the rate of job-to-job transitions is taken to be an important measure of labor market slack (e.g., Birinci et al., 2022; Moscarini and Postel-Vinay, 2023; Faccini and Melosi, 2023).

Our paper also relates to the broader empirical literature studying labor market flows and their implications for aggregate labor market variables such as employment and unemployment (e.g., Davis, Faberman and Haltiwanger, 2006; Shimer, 2012; Elsby, Hobijn and Şahin, 2015). A primary and distinctive contribution of our paper is that we document a large cyclical role for quits from employment to nonparticipation, which we show to be particularly important for understanding the cyclical dynamics of the employment-population ratio in response to a monetary policy shock.

Elsby, Hobijn and Şahin (2015) devote particular attention to flows between unemployment and nonparticipation. While EHS study the importance of these flows for cyclical variation in unemployment and labor force participation, we emphasize

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<sup>6</sup>As we discuss below, our findings are similar to those of Elsby, Michaels and Solon (2009), Fujita and Ramey (2009), and Elsby, Hobijn and Şahin (2015), whose findings suggest a more important role for separations in explaining unconditional business cycle variation in unemployment.

the contribution of flows between U and N to cyclical variation in the employment-population ratio. As we show, flows between U and N are quantitatively more important for employment dynamics than unemployment dynamics in response to a monetary policy shock. In addition, we document the importance of quits from employment to nonparticipation as an additional and equally important supply-related flow.

Our empirical analysis is also closely related to the literature on monetary policy VARs and high-frequency identification (e.g., Stock and Watson, 2012; Gertler and Karadi, 2015; Ramey, 2016; Bauer and Swanson, 2023b). In contrast to these papers, we extend our VAR to include labor market flows in order to study the interaction between monetary policy and the labor market and quantify the importance of different flows for the responses of labor market aggregates.

Finally, our paper relates to the large literature on New Keynesian models with sticky wages (e.g., Christiano, Eichenbaum and Evans, 2005; Smets and Wouters, 2007; Auclert, Rognlie and Straub, 2018; Auclert, Bardóczy and Rognlie, 2021). As these models incorporate sticky wages to fit the data, they assume that labor is demand-determined in the short run. As a result, changes in households' labor supply have no meaningful quantitative impact on the response of labor to shocks.<sup>7</sup> A similar absence of a role for labor supply is reflected in the smaller literature on New Keynesian models that incorporate a search and matching framework for unemployment, but assume perfectly inelastic labor supply (e.g., Gertler, Sala and Trigari, 2008; Christiano, Eichenbaum and Trabandt, 2016; Graves, 2022). In contrast to these papers, we impose minimal structure on the data to recover labor demand and supply responses to a monetary policy shock, and we find that changes in labor supply play an important role in shaping those responses.

## 2. DATA AND METHODOLOGY

We begin by describing the labor market flows data and its relationship to aggregate labor market variables such as employment and unemployment. We then identify labor market flows (and components of flows) that are plausibly driven by labor supply considerations. Finally, we describe how to estimate the responses of labor market flows to exogenous variation in monetary policy by extending a standard structural monetary policy VAR with high-frequency identification.

**2.1. Labor Market Stocks and Flows.** We study the cyclical behavior of aggregate labor market stocks and flows. Our primary data source for gross worker flows is the longitudinally linked data from the monthly Current Population Survey (CPS) from 1978 to 2019. We organize our discussion of labor market stocks and flows in

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<sup>7</sup>Broer et al. (2020) demonstrate this as a robust characteristic of both the representative agent and heterogeneous agent sticky-wage New Keynesian model under frictionless labor markets: Under a conventional calibration for parameters determining the overall degree of wage stickiness, wages show very little response to a monetary policy shock, and thus “labour usage is ‘demand-determined’” (p. 98). Huo and Ríos-Rull (2020) and Broer et al. (2023) offer further discussion of demand-determined labor under wage stickiness.

TABLE 1. Cyclicalities of Labor Market Stocks

	Employment- population ratio	Unemployment	Labor force participation
mean( $x$ )	61.14	6.19	65.16
std( $x$ )/std( $Y$ )	0.72	8.26	0.23
corr( $x$ , $Y$ )	0.83	-0.85	0.35

*Note:*  $x$  denotes the variable in each column,  $Y$  denotes HP-filtered log real GDP. Standard deviations and correlations in the second and third rows are computed for HP-filtered quarterly averages.

terms of three distinct labor market states: employment (E), unemployment (U), and nonparticipation (N).

Table 1 presents summary statistics for three standard labor market stock measures: the employment-to-population ratio,  $E/(E+U+N)$ , the unemployment rate,  $U/(E+U)$ , and the labor force participation rate,  $(E+U)/(E+U+N)$ . The cyclical properties of these first three labor market aggregates are well known: the employment-population ratio is procyclical but not very volatile, the unemployment rate is countercyclical and highly volatile, and the labor force participation rate is only modestly procyclical and not very volatile.

The dynamic behavior of the labor market stocks E, U, and N can be understood by the flows of workers between these three states. Labor markets exhibit considerable churn, with positive gross flows in both directions between any two states. Let  $p_{X,Y}$  denote the fraction of workers in labor market state  $X$  moving to state  $Y$ . Labor market stocks and flows are then related by the Markov process

$$\begin{bmatrix} E \\ U \\ N \end{bmatrix}_{t+1} = \begin{bmatrix} 1 - p_{EU} - p_{EN} & p_{UE} & p_{NE} \\ p_{EU} & 1 - p_{UE} - p_{UN} & p_{NU} \\ p_{EN} & p_{UN} & 1 - p_{NE} - p_{NU} \end{bmatrix}_{t+1} \begin{bmatrix} E \\ U \\ N \end{bmatrix}_t. \quad (1)$$

Equation (1) can be extended to study the dynamics of labor market stocks across longer time periods. Let  $P_{t+1}$  denote the transition matrix in equation (1). Given the vector  $[E, U, N]_t'$  and a time series of transition matrices  $\{P_{t+j}\}_{j=1}^k$ , we can express labor market stocks at  $t+k$  as

$$\begin{bmatrix} E \\ U \\ N \end{bmatrix}_{t+k} = \left( \prod_{j=1}^k P_{t+j} \right) \begin{bmatrix} E \\ U \\ N \end{bmatrix}_t. \quad (2)$$

Thus, given an initial condition, we can understand the dynamic properties of labor market stocks through the time series of labor market flows. In Section 4, we use this relationship to help understand how shifts in supply-driven labor market flows account for the response of labor market stocks to monetary policy surprises.

TABLE 2. Average Transition Probabilities Across Labor Market States

<i>From</i>	<i>To</i>		
	E	U	N
E	0.954	0.014	0.030
U	0.255	0.483	0.227
N	0.046	0.025	0.926

TABLE 3. Cyclicity of Labor Market Flows

	$p_{EU}$	$p_{EN}$	$p_{UE}$	$p_{UN}$	$p_{NE}$	$p_{NU}$
mean	0.014	0.030	0.255	0.227	0.046	0.025
std( $x$ )/std( $Y$ )	5.43	2.40	5.71	4.16	2.84	5.26
corr( $x, Y$ )	-0.81	0.51	0.78	0.71	0.66	-0.67

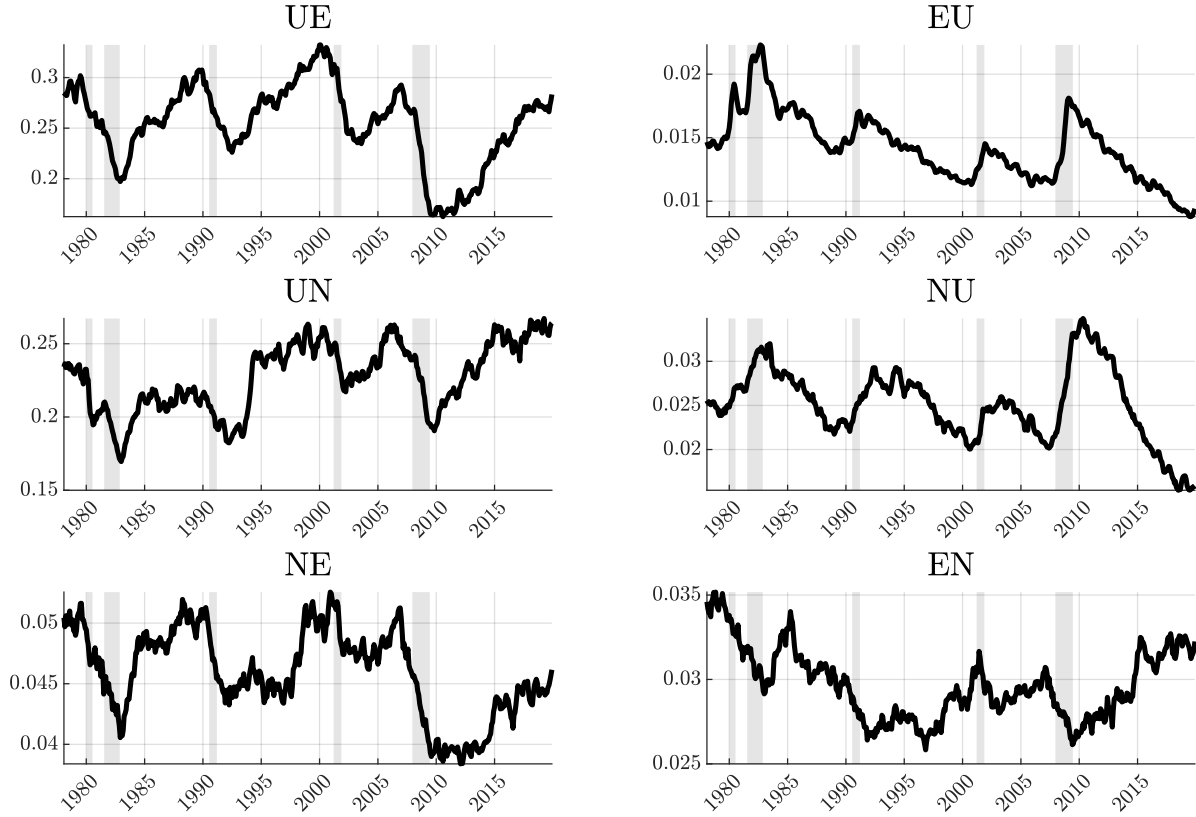
*Note:*  $x$  denotes the variable in each column,  $Y$  denotes HP-filtered log real GDP. Standard deviations and correlations in the second and third rows are computed for HP-filtered quarterly averages.

Table 2 reports the average labor market transition matrix  $\bar{P}_t$  estimated over our sample, 1978–2019.<sup>8</sup> Table 3 summarizes the cyclical properties of each of the six HP-filtered off-diagonal transition probabilities. The full time series of transition probabilities for our sample is plotted in Figure 1. The properties of these transition probabilities have been well documented in the literature (e.g., Shimer, 2012; Elsby et al., 2015; Krusell et al., 2017). Here we simply note that we consider flows between nonparticipation and unemployment as being driven by labor supply considerations. The procyclicality of UN flows and countercyclicality of NU flows is evidence of greater job-seeking behavior among the non-employed during downturns. Elsby, Hobijn and Şahin (2015) show that this accounts for about one-third of fluctuations in the unemployment rate.

Movements between unemployment and nonparticipation are not the only way we identify a significant role for labor supply responses. In the next section, we decompose EU and EN flows in a way that allows us to distinguish between labor demand and labor supply forces. Doing so will also shed light on the finding that EU flows are strongly countercyclical while EN flows are procyclical.

<sup>8</sup>We seasonally adjust each flow using the X-13ARIMA-SEATS seasonal adjustment software provided by the Census Bureau. Given our subsequent focus on quits and layoffs from non-employment, we do not adjust for time aggregation bias. All our results are robust to corrections for time aggregation, where such corrections are possible.

FIGURE 1. Labor Market Flows



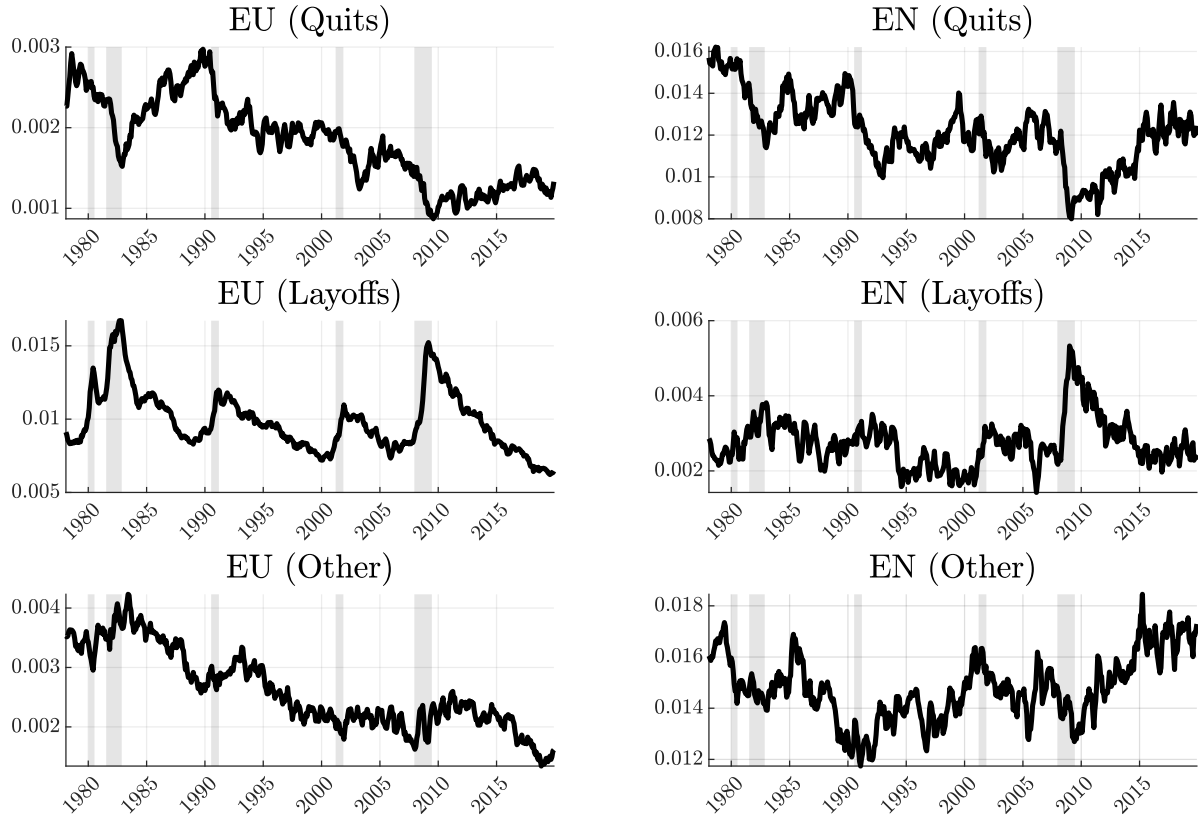
*Note:* Transition rates are calculated using CPS micro-data. All series are smoothed using a centered 5-month moving average.

**2.2. Decompositions of Separations into Quits and Layoffs.** To understand the roles of labor demand and labor supply in driving EU and EN transitions, we decompose EU and EN flows into “quits”, “layoffs”, and “other separations” using the additional survey detail that is provided in the CPS. For example, if a worker transitioning from E to U lists the reason for unemployment in the CPS as being a “job leaver”, then we classify that transition as a quit, while if they report being a “job loser/on layoff”, we classify that transition as a layoff. Additional details are provided in Appendix A.1. We interpret layoffs as being driven by factors related to labor demand and quits as being driven by factors related to labor supply. Having this decomposition will be important when we want to hold the response of supply-driven labor market flows constant in Section 4.

The left column of Figure 2 shows the time series of EU flows for quits, layoffs, and other separations, and the left panel of Table 4 summarizes their cyclical properties. About 70% of EU flows are due to layoffs, and these flows are highly countercyclical and volatile. Another 10–15% are due to quits, and although these flows are similarly



FIGURE 2. Decomposition of Employment-to-Unemployment and Employment-to-Nonparticipation Flows



*Note:* Employment-unemployment (EU) and employment-nonparticipation (EN) flows are decomposed into quits, layoffs and other separations as explained in Appendix A.1. All series are smoothed using a centered 5-month moving average.

volatile, they are procyclical. The remaining 15–20% of EU flows that cannot be categorized as either layoffs or quits are only weakly countercyclical.

Thus, consistent with Elsby, Michaels and Solon (2009), Ahn (2023), and others, our decomposition of EU flows data suggests that workers are less likely to quit a job to unemployment during a recession, but are more likely to be fired. Since layoffs account for the vast majority of EU flows, the overall cyclicity of the EU rate is driven by the countercyclicity of layoffs.

Although many authors have studied the cyclicity and composition of EU flows, much less attention has been paid to EN flows, despite the fact that EN flows are substantially larger than EU flows (see Table 2). In the right column of Figure 2 and the right-hand panel of Table 4, we provide a similar—and to our knowledge,

TABLE 4. Components of EU and EN flows

	EU flows				EN flows			
	Total	Quits	Layoffs	Other	Total	Quits	Layoffs	Other
mean	0.014	0.002	0.010	0.003	0.030	0.012	0.003	0.015
std( $x$ )/std( $Y$ )	5.16	8.16	7.88	6.26	2.47	5.89	14.46	4.61
corr( $x$ , $Y$ )	-0.82	0.61	-0.83	-0.11	0.49	0.53	-0.44	0.28

*Note:* The process for decomposing EU and EN flows into quits, layoffs and other separations is described in Appendix A.1. Standard deviations and correlations in the second and third rows are computed for HP-filtered quarterly averages.

novel—decomposition of EN flows into layoffs, quits, and other separations.<sup>9</sup> As was the case for EU flows, EN layoffs are countercyclical and EN quits are procyclical. But, in contrast to EU flows, quits are much more important than layoffs for EN flows, implying a much more important role for both the magnitude and cyclicity of quits to non-employment—and hence labor supply factors—than has been previously recognized. For example, the portion of EN flows that can be identified as quits is of similar magnitude to the entirety of EU flows. Our finding of a quantitatively significant role for quits to nonparticipation stands in sharp contrast to much of the literature (e.g., Faberman and Justiniano, 2015), which often equates quits with job-to-job transitions.<sup>10</sup>

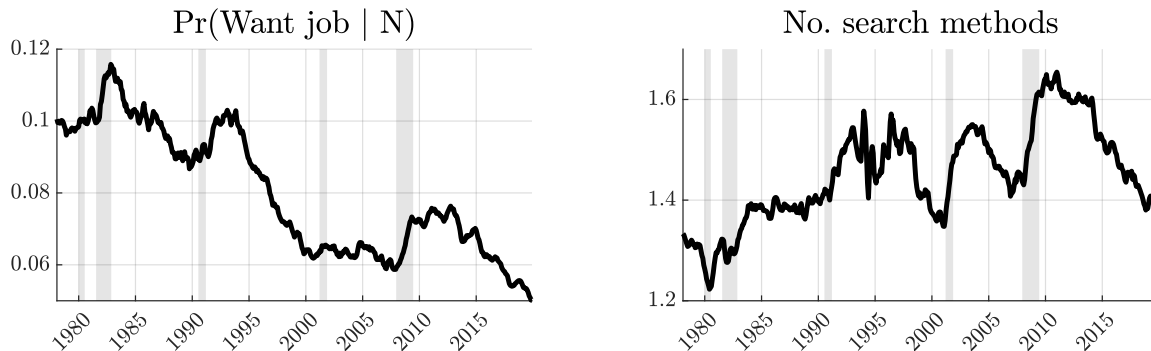
**2.3. The Intensive Margin of Labor Supply.** In our analysis of the labor supply response to monetary policy, we will also study the intensive margin of labor supply for the non-employed—i.e., search intensity.<sup>11</sup> We first study the time series behavior of the fraction of nonparticipants who want a job despite not being engaged in active search, shown in the left panel of Figure 3. During recessions, the fraction of workers in nonparticipation who express a desire for work increases markedly and persistently. This increase in the desire to work among nonparticipants is economically relevant for understanding overall labor flows: while the rate at which workers in N move to E is five times smaller than that of workers in U, the rate at which workers in N *who want work* move to E is just over half that of workers in U.

<sup>9</sup>As we discuss in Appendix A.1, a larger fraction of EN transitions cannot be categorized (individuals classified as retired or disabled are a significant portion of this category). The cyclical behavior of such uncategorized EN flows is similar to that of quits to nonparticipation.

<sup>10</sup>Faberman and Justiniano (2015) explain their use of the JOLTS quit rate as a proxy for the job-to-job transition rate from the finding of Elsby, Hobijn and Sahin (2010) that only 16% of quits lead to unemployment. Our findings suggest that a large fraction of JOLTS quits may reflect quits to nonparticipation rather than job-to-job transitions.

<sup>11</sup>Cantore et al. (2020) study the response of the intensive margin of labor supply among the employed to a monetary policy surprise, offering evidence that low-income workers in employment increase their hours worked in response to a contractionary monetary policy shock.

FIGURE 3. Intensive Margins of Labor Supply



*Note:* We calculate the probability of non-participants that want a job and the number of search methods of the unemployed using the procedure described in Appendix A.2. All series are smoothed using a centered 5-month moving average.

Second, we study the number of active search methods of workers in  $U$  as a measure of search intensity. This measure has been used elsewhere in the literature to show that search is countercyclical, including Osberg (1993), Shimer (2004), and Mukoyama, Patterson and Şahin (2018). Mukoyama, Patterson and Şahin (2018) go further, showing from the American Time Use Survey that time spent searching for a job is essentially linear in the number of search methods. Relative to these papers, we construct a consistent measure of the number of search methods starting from 1978 rather than 1994, shown in the right panel of Figure 3.

**2.4. Monetary Policy VARs and High-Frequency Identification.** Several recent papers have used high-frequency interest rate changes around the Federal Reserve’s Federal Open Market Committee (FOMC) announcements, or *monetary policy surprises*, to estimate the effects of monetary policy in a VAR (e.g., Cochrane and Piazzesi, 2002; Faust et al., 2003, 2004; Stock and Watson, 2012, 2018; Gertler and Karadi, 2015; Ramey, 2016; Bauer and Swanson, 2023b). Monetary policy surprises are appealing in these applications because their focus on interest rate changes in a narrow window of time around FOMC announcements plausibly rules out reverse causality and other endogeneity problems, as we discuss below.

The core of our VAR includes six monthly macroeconomic variables: the log of industrial production, the unemployment rate, the labor force participation rate, the log of the consumer price index, the Gilchrist and Zakrajšek (2012) excess bond premium, and the two-year Treasury yield.<sup>12</sup> This specification is very similar to

<sup>12</sup>Industrial production, the unemployment rate, the labor force participation rate, the CPI, and the two-year Treasury yield are from the Federal Reserve Bank of St. Louis FRED database. We include the GZ credit spread for consistency with Bauer and Swanson (2023b) and because Caldara and Herbst (2019) found it to be important for the estimation of monetary policy VARs. As discussed in Swanson and Williams (2014) and Gertler and Karadi (2015), the two-year Treasury yield was

Bauer and Swanson (2023b), except that we include labor force participation as an additional variable, given our focus on the labor market (and we will also extend the core VAR to include labor market flow variables, below). We stack these six core variables into a vector  $Y_t$  and estimate the reduced-form VAR,

$$Y_t = \alpha + B(L)Y_{t-1} + u_t, \quad (3)$$

where  $\alpha$  is a constant,  $B(L)$  a matrix polynomial in the lag operator, and  $u_t$  is a  $6 \times 1$  vector of serially uncorrelated regression residuals, with  $\text{Var}(u_t) = \Omega$ . We estimate regression (3) from February 1978 to December 2019 via ordinary least squares with 6 monthly lags.

We follow standard practice and assume that the economy is driven by a set of serially uncorrelated structural shocks,  $\varepsilon_t$ , with  $\text{Var}(\varepsilon_t) = I$  (see, e.g., Ramey, 2016). Since the dynamics of the economy are determined by  $B(L)$ , the effects of different structural shocks  $\varepsilon_t$  on  $Y_t$  are completely determined by differences in their impact effects on  $Y_t$  in period  $t$ , given by

$$u_t = S\varepsilon_t, \quad (4)$$

which we assume are linear, with  $S$  a matrix of appropriate dimensions. We assume that one of the structural shocks is a “monetary policy shock”, and we order that shock first in  $\varepsilon_t$  and denote it by  $\varepsilon_t^{mp}$ . The first column of  $S$ , denoted  $s_1$ , then describes the impact effect of the structural monetary policy shock  $\varepsilon_t^{mp}$  on  $u_t$  and  $Y_t$ .

To identify the impact effect  $s_1$  of the monetary policy shock  $\varepsilon_t^{mp}$ , we use high-frequency identification: Let  $z_t$  denote our set of high-frequency interest rate changes (surprises) around FOMC announcements and Fed Chair speeches, converted to a monthly series by summing over all the high-frequency surprises within each month.<sup>13</sup> In order for  $z_t$  to be a valid instrument for  $\varepsilon_t^{mp}$ , it must satisfy an instrument *relevance* condition,

$$E[z_t \varepsilon_t^{mp}] \neq 0, \quad (5)$$

and an instrument *exogeneity* condition,

$$E[z_t \varepsilon_t^{-mp}] = 0, \quad (6)$$

where  $\varepsilon_t^{-mp}$  denotes any element of  $\varepsilon_t$  other than the first (Stock and Watson, 2012, 2018).

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largely unconstrained during the 2009–15 zero lower bound period, making it a better measure of the overall stance of monetary policy than a shorter-term interest rate like the federal funds rate.

<sup>13</sup>High-frequency interest rate changes around FOMC announcements and Fed Chair speeches are from Swanson and Jayawickrema (2023) and include all 323 FOMC announcements from 1988–2019 and all 404 press conferences, speeches, and Congressional testimony by the Fed Chair (“speeches” for brevity) over the same period that had potential implications for monetary policy, according to financial market commentary in the *Wall Street Journal* or *New York Times*. This is somewhat larger than the set of speeches in Bauer and Swanson (2023b), who used an earlier version of the data that contained only the 295 most influential Fed Chair speeches. We compute  $z_t$  in the same way as Bauer and Swanson, taking the first principal component of the change in the current-quarter and 1-, 2-, and 3-quarter-ahead Eurodollar future rates in a narrow window of time around each announcement, which helps capture changes in forward guidance as well as the federal funds rate.

The appeal of high-frequency monetary policy surprises is that they very plausibly satisfy conditions (5)–(6). First, FOMC announcements and Fed Chair speeches are an important part of the news about monetary policy each month, so the correlation between  $z_t$  and  $\varepsilon_t^{mp}$  in (5) should be positive and large. Importantly, including Fed Chair speeches provides us with a much more relevant instrument than using FOMC announcements alone, as shown by Bauer and Swanson (2023b). Second, high-frequency monetary policy surprises capture interest rate changes in narrow windows of time around policy announcements. It’s therefore unlikely that other structural shocks in  $\varepsilon_t^{-mp}$  are significantly affecting financial markets at the same time, so that these other shocks should be uncorrelated with  $z_t$ , implying (6).<sup>14</sup>

Given our external instrument  $z_t$ , we estimate the impact effects  $s_1$  in the SVAR as described in Stock and Watson (2012, 2018), Gertler and Karadi (2015), and Bauer and Swanson (2023b). For concreteness, order the two-year Treasury yield first in  $Y_t$ , and denote it by  $Y_t^{2y}$ . We then estimate the regression

$$Y_t = \tilde{\alpha} + \tilde{B}(L)Y_{t-1} + s_1 Y_t^{2y} + \tilde{u}_t \quad (7)$$

via two-stage least squares, using  $z_t$  as the instrument for  $Y_t^{2y}$ .<sup>15</sup> It’s straightforward to show that (5)–(6) imply that (7) produces an unbiased and consistent estimate of  $s_1$ , with the first element normalized to unity. (In our empirical results below, we rescale  $s_1$  so that the first element has an impact effect of 25 basis points, rather than 1 percentage point.) Once we have estimated  $s_1$ , the impulse response functions for each variable follow from the estimated matrix lag polynomial  $B(L)$  in (3).<sup>16</sup>

Finally, we follow the prescriptions of Bauer and Swanson (2023a,b) and adjust our high-frequency instrument  $z_t$  by projecting out any correlation with recent macroeconomic and financial news. As Bauer and Swanson (2023b) show, this purges our estimates of a significant “Fed Response to News” endogeneity bias.

### 3. ESTIMATES

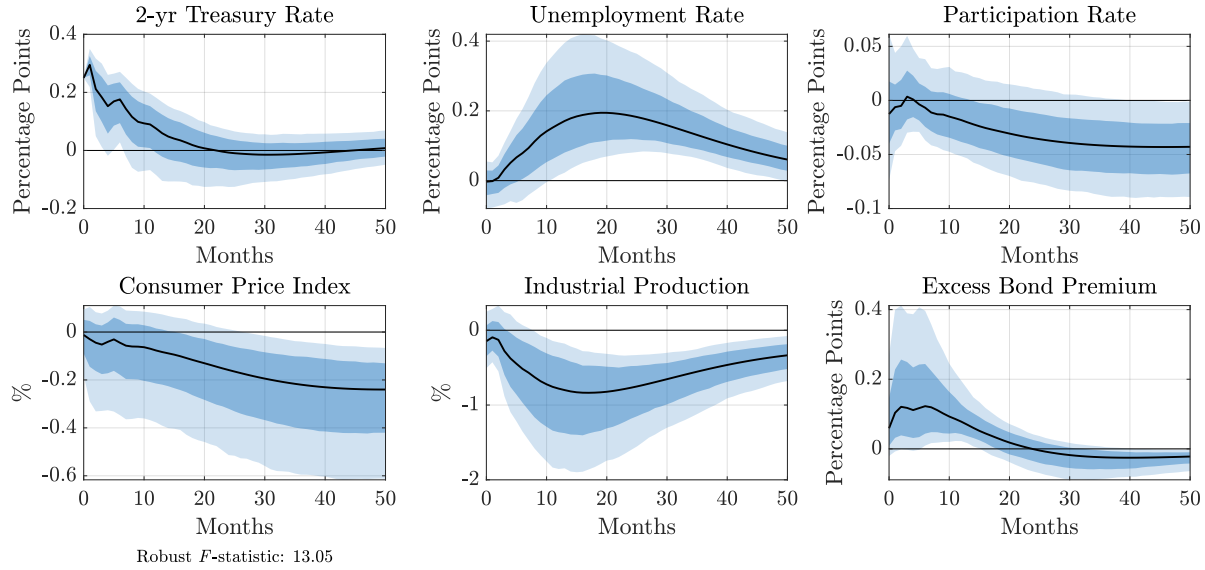
We present several sets of results. First, we report estimated baseline impulse response functions (IRFs) for the core six-variable VAR described above. Second, we extend this core VAR to include labor market flow variables and report IRFs for labor market flows. Third, we augment the core VAR to include the quits and layoffs components of EU and EN flows to provide additional insights into the response of labor supply. Fourth, we augment our core VAR to include intensive measures of labor supply and study their responses to monetary policy.

<sup>14</sup>Swanson and Jayawickrema (2023) use narrow intradaily windows around these announcements and are careful to avoid overlapping with any other macroeconomic data releases.

<sup>15</sup>One can obtain the same point estimates for  $s_1$  by regressing the reduced-form residuals  $u_t$  from (3) on  $u_t^{2y}$  using  $z_t$  as the instrument. Stock and Watson (2018) recommend using (7) to avoid a generated regressor and correctly estimate the first-stage  $F$ -statistic of the instrument.

<sup>16</sup>Note that the sample for (7) used to estimate  $s_1$  does not have to be the same as for the reduced-form VAR in (3) used to estimate  $B(L)$ . Our high-frequency monetary policy surprises are only available from 1988:1–2019:12, while we estimate  $B(L)$  over the longer sample 1978:2–2019:12.

FIGURE 4. Response of Aggregate Variables to a Monetary Policy Shock



*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock in the baseline VAR. Solid black lines report impulse response functions, while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. See text for details.

**3.1. Baseline VAR Impulse Responses to a Monetary Policy Shock.** Estimated IRFs from the core six-variable monetary policy VAR described above are presented in Figure 4. The solid black line in each panel reports the IRF, while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals, computed as in Jentsch and Lunsford (2019).

The impact effect of a monetary policy shock on the 2-year Treasury yield is normalized to a 25bp tightening. After impact, the 2-year Treasury yield increases slightly and then gradually returns to steady state over the next 2.5 years. The Gilchrist and Zakrajšek (2012) excess bond premium, in the bottom right panel, increases by 5bp on impact and rises for several months before gradually returning to steady state. The other four variables—unemployment, labor force participation, industrial production, and the CPI—respond more sluggishly, with essentially no effect on impact. After a few months, industrial production begins to decline and the unemployment rate starts to rise, followed by a decline in labor force participation a few months later and, last of all, a decrease in the CPI. The peak effect is about 0.2 percentage points for the unemployment rate, almost  $-1$  percent for industrial production,  $-0.05$  percentage points for the labor force participation rate, and  $-0.2$  percent for the CPI. These responses are similar to those from monetary policy VARs estimated by other authors, such as Bauer and Swanson (2023b), and are consistent

with the aggregate economy weakening moderately and inflation falling slightly after a monetary policy tightening.<sup>17</sup>

**3.2. Responses of Labor Market Flows to a Monetary Policy Shock.** We next extend our core six-variable monetary policy VAR to include labor market flows. Extending the VAR to include all six labor market flows (EN, EU, NE, NU, UE, and UN) at once would introduce too many parameters into the VAR, resulting in poor estimates and overfitting, so we extend the baseline VAR with one labor market flow variable at a time (this is the same approach used by Gertler and Karadi (2015) to analyze financial market responses to monetary policy shocks). The results for each labor market flow are reported in Figure 5. Each panel in Figure 5 corresponds to a separate seven-variable VAR—the six variables in the baseline VAR, above, plus the labor market flow variable listed at the top of the panel.<sup>18</sup> Within each panel, we also report the average rate for that flow in the inset box—for example, 1.4 percent of employed workers move to unemployment each month, on average, while about 25.5 percent of unemployed individuals move to employment.

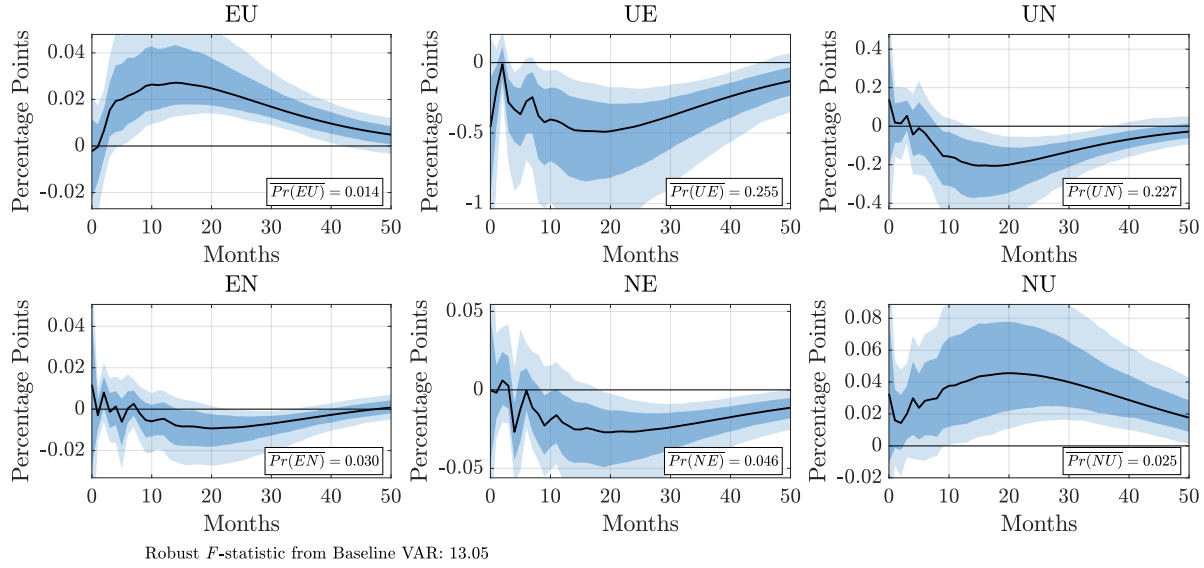
In response to a 25bp monetary policy tightening, the labor market flows in Figure 5 respond gradually, with either a small or statistically insignificant effect on impact and a peak effect after about one and a half years. The flow from employment to unemployment (EU) in the top left panel increases significantly after the monetary policy tightening, which is consistent with a decline in labor demand due to a weakening aggregate economy. This increase may seem small at first glance—about 0.025 percentage points at its peak—but it is sizeable relative to the steady-state flow of about 1.4 percent each month (as reported in the inset box). Moreover, the increase in EU flows in response to an identified monetary policy shock is highly persistent, especially compared to the more transitory increase in EU flows seen at the start of a recession (e.g., Elsby et al., 2009).

The flow from unemployment to employment (UE) in the top middle panel of Figure 5 decreases significantly in response to the monetary policy tightening, again consistent with a weakening economy and lower labor demand. However, previous authors, such as Faia et al. (2022), have often failed to find a significant response here. There are two likely reasons why our estimates are more significant: First, our high-frequency measure of monetary policy surprises purges those surprises of correlation with previous economic and financial data releases. Bauer and Swanson (2023b) show that failing to orthogonalize the monetary policy surprises in this way results in impulse responses that are biased back towards zero. Second, our measure

<sup>17</sup>Note that, if the participation rate is interpreted as a measure of labor supply, as in Erceg and Levin (2014), then the decline of the participation rate in Figure 4 might be interpreted as evidence of a procyclical labor supply response to monetary policy. We show below that labor market flows associated with a labor supply response are consistent with a *countercyclical* labor supply response to monetary policy. We also show below that procyclical participation and countercyclical labor supply flows are not inconsistent, but rather that the response of participation to monetary surprises should not be taken as a measure of labor supply at high frequencies.

<sup>18</sup>IRFs for the six baseline variables are not reported in Figure 5 in the interest of space, and because they are very similar to those from the baseline VAR in Figure 4.

FIGURE 5. Response of Labor Market Flows to a Monetary Policy Shock



*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given labor market flow variable to the baseline VAR from Figure 4. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Robust F-statistic reported for baseline VAR from Figure 4. See text for details.

of monetary policy surprises includes speeches by the Fed Chair as well as FOMC announcements, which Bauer and Swanson (2023b) show provides a much more powerful instrument than FOMC announcements alone.<sup>19</sup> As a result, our estimates of the IRFs in Figure 5 are likely to be less biased and more precise than those estimated elsewhere in the literature.

Given the conventional wisdom that monetary policy has little effect on labor supply, more surprising in Figure 5 is the response of the flow from nonparticipation to unemployment (NU) in the bottom right panel. In response to the monetary policy tightening, the rate at which workers enter the labor force to look for a job (i.e., transitioning from N to U) *increases* significantly. Simultaneously, the symmetric flow from unemployment to nonparticipation (UN) in the top right panel *declines* in response to the monetary policy shock. Taken on their own, the increase in NU flows and decrease in UN flows tilts the composition of nonemployment (unemployment + nonparticipation) towards the unemployed, increasing the fraction of active searchers among the population of nonemployed. Such a pattern is consistent with labor supply increasing in response to a weaker economy.

Finally, the flow from nonparticipation to employment (NE) in the bottom middle panel of Figure 5 responds similarly to the UE flow, but by a smaller amount. The flow from employment to nonparticipation (EN) in the bottom left panel declines

<sup>19</sup>See Figures C.6 and C.7 of the Appendix and the discussion therein for support of our interpretation of the difference in estimates.



modestly. We show in the next section that a labor supply response is crucial for explaining why the EN rate declines in response to a contractionary shock, while the EU rate rises significantly.

Overall, the labor market flow responses in Figure 5 suggest that monetary policy has *both* a labor demand and a labor supply effect. The EU, UE, and NE flow responses are all consistent with a weakening economy and weaker labor demand. On the other hand, the NU and UN flows—and as we will show, the EN flows, too—suggest an *increase* in labor supply. Intuitively, households that face a weakening economy and worse employment prospects may increase their labor supply in order to maintain their income and consumption.

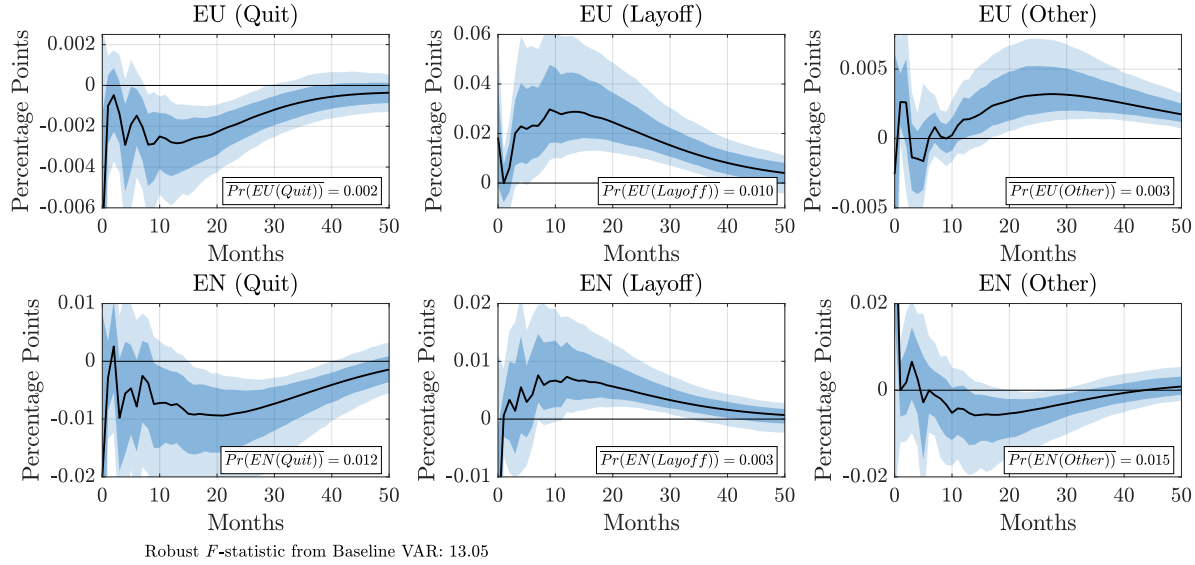
As a robustness check on these results, Appendix Figure C.3 repeats the analysis in Figure 5, but using labor market flow measures that hold the composition of the labor force constant in response to the shock, as in Elsby, Hobijn and Şahin (2015). The results in Figure C.3 are essentially identical to those in Figure 5, implying that changes in the composition of the labor force over the business cycle are not driving our results. We also check that the increase in UN flows is not an artifact of an increasing share of workers in unemployment due to layoffs—see Appendix Figure C.4. The IRF for the total UN flow is similar to the separate IRFs for workers in unemployment due to quits versus layoffs. Thus, our finding of diminished UN flows is not driven by cyclical changes in the shares of quits versus layoffs among workers in unemployment.

**3.3. Responses of Quits and Layoffs to a Monetary Policy Shock.** We provide further evidence of the labor demand and labor supply effects of monetary policy by looking at the differential responses of quits and layoffs to a monetary policy shock. Figure 6 reports IRFs for the quit, layoff and other separation components of both EU and EN flows (defined in Section 2.2) to a 25bp monetary policy tightening. Each of these variables is appended to our core six-variable VAR one at a time, just as in Section 3.2.

We find that layoffs to both unemployment and nonparticipation rise significantly after a monetary policy tightening, consistent with a weakening economy and lower labor demand. In contrast, the quit rate to both unemployment and nonparticipation significantly *decreases* after a tightening, consistent with an increase in labor supply. The portion of EU flows that cannot be definitively attributed to layoffs or quits increases, while the unattributed EN flow rate declines slightly.<sup>20</sup> As layoffs are a much larger fraction of EU flows than are quits, the overall response of EU flows tends to track the layoffs component. The opposite is true for EN flows: the modest decline in the overall EN rate in response to a contractionary monetary policy shock occurs as the decline in the quit rate to nonparticipation outweighs the rise in layoffs to nonparticipation.

<sup>20</sup>While we do not categorize it as such, this is also consistent with an increase in labor supply. For example, a tightening of monetary policy may lead to a delay in retirement (which constitutes a significant fraction of other separations to nonparticipation).

FIGURE 6. Decomposition of E-U and E-N Responses



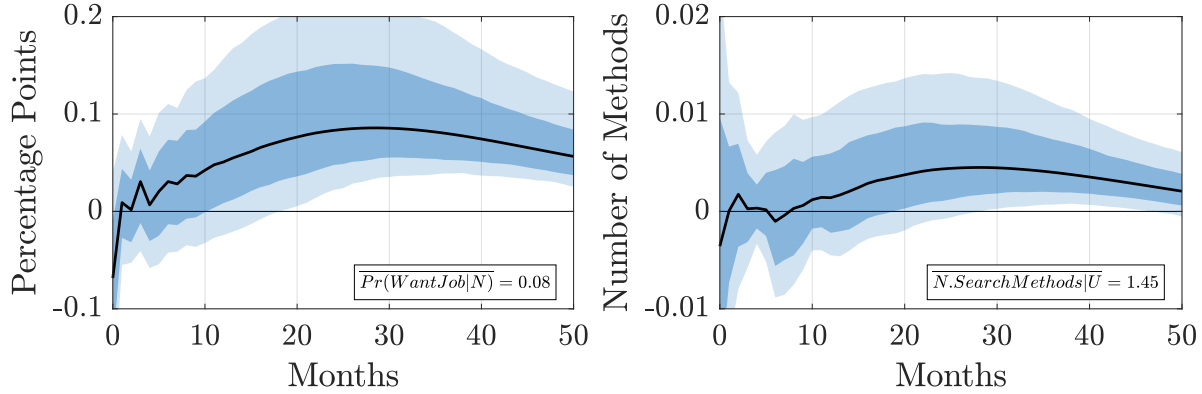
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given labor market flow variable to the baseline VAR from Figure 4. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Inset boxes report average transition rates. Robust  $F$ -statistic reported for baseline VAR from Figure 4. See text for details.

Our findings might also be considered surprising in light of a prominent view summarized by Shimer (2012): Under efficient separations à la Barro (1977), where wages are not allocative, the distinction between quits and layoffs is economically irrelevant. The differential responses shown in Figure 6 can be understood through an allocative role for wages, where wages are sufficiently sticky that they cannot be lowered enough to prevent a layoff in response to a contractionary monetary policy surprise, or raised enough to prevent a quit after an expansionary monetary policy surprise. In the Appendix, we show that wages move modestly in response to the identified monetary policy shocks, consistent with this interpretation, which is also supported by Jäger et al. (2022) and Davis and Krolkowski (2022).

**3.4. Responses of Intensive Margins of Labor Supply.** For additional evidence on the response of labor supply to a monetary policy shock, we examine the response of the intensive margins of labor supply for the non-employed. Such responses reflect an increased desire to work and may influence the rate at which workers move to employment.

As in Section 2.3, we first look at the fraction of nonparticipants who report wanting a job despite not being engaged in active search. As discussed earlier, such

FIGURE 7. Response of Intensive Margins of Labor Supply



Robust  $F$ -statistic from Baseline VAR: 13.05

*Note:* Our measurement of the fraction of nonparticipants that want a job and the number of search methods used by unemployed individuals is described in Section 2.3. Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 4. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Inset boxes report average probabilities. Robust  $F$ -statistic reported for baseline VAR from Figure 4. See text for details.

workers find employment at a substantially higher rate than nonparticipants reporting no desire to work.<sup>21</sup> The left panel of Figure 7 shows the IRF for the fraction of nonparticipants who report a desire to work. There is a robust and persistent increase in the desire to work among workers in nonparticipation in response to the monetary policy surprise. Hence, the movement of workers from nonparticipation to unemployment in response to a monetary policy surprise may be considered part of a broader labor supply response within non-employment.

Next, we look at the number of job search methods used by workers in unemployment. As discussed in Section 2.3, this metric has been adopted elsewhere in the literature and has been shown to be highly correlated with time spent looking for a job, e.g., Osberg (1993), Shimer (2004), and Mukoyama, Patterson and Şahin (2018). Moreover, unemployed workers who use two or more search methods are around 15% more likely to transition to employment than those that only use one search method. The right panel of Figure 7 shows the IRF for the number of search methods of unemployed workers. After a contractionary monetary policy surprise, the average number of search methods used by unemployed workers gradually increases, peaking at around 24 months.

These findings show that, even within distinct labor market states, workers exhibit behavioral responses to a contractionary monetary policy surprise consistent with an increase in labor supply. To the extent that active search is costly but increases the

<sup>21</sup>Non-participants that report wanting a job are almost four times more likely to move to employment in the following month than non-participants who do not want a job.

probability of finding a job, these findings offer further evidence that workers place greater value on employment when the economy is weak.

**3.5. Responses of Other Labor Market Variables.** In Appendix B, we study the response of other labor market variables to monetary policy shocks. First, we show that the job-to-job transition rate shows no significant response. Thus, we fail to find clear evidence supporting an “offer-matching theory of inflation,” e.g., Birinci et al. (2022), Moscarini and Postel-Vinay (2023), and Faccini and Melosi (2023).<sup>22</sup> As discussed in the Appendix, we suspect that a measure of job-to-job transitions that only includes transitions to higher-paying jobs might be more appropriate for assessing such theories.

Next, we show that a contractionary monetary policy shock leads to a significant decline in vacancy posting. Through the lens of a matching function, this shows that the decline in the UE and NE transition rates is not simply due to an increase in the number of unemployed individuals. Finally, we show that individual-level wage growth responds very little to monetary policy shocks. This offers support to the view outlined in Section 3.3, by which wage stickiness helps to explain the differential movement of quits and layoffs.

#### 4. FLOW-BASED ACCOUNTING FOR THE DYNAMICS OF LABOR MARKET STOCKS

The previous section documents that labor market flows respond to a contractionary monetary policy surprise in a manner consistent with a decline in labor demand and an increase in labor supply. Here, we analyze the extent to which the responses of the overall unemployment rate, employment-population ratio, and labor force participation rate are driven by the responses of the various underlying labor market flows. To account for the contribution of a particular flow towards the overall response of a labor market stock, we compute the hypothetical response of the stock when the given flow is held fixed, relying on equation (1), which expresses the evolution of aggregate labor market stocks as a function of labor market flows. Following the logic of Shimer (2012) and Elsby et al. (2015), to the extent that the implied response of the hypothetical stock deviates from that of the actual stock, we conclude that the flow in question plays an important role in shaping the overall response of the stock.

We develop two main findings. First, we uncover a more important role for cyclical variation in flows from employment to unemployment (i.e., layoffs) in determining the response of unemployment to a monetary policy shock than is typically found in the literature studying unconditional business cycle variation (e.g., Shimer (2012)). Second, we show that the response of supply-related labor market flows to a monetary policy shock attenuates the decline in employment by roughly one-half, suggesting a quantitatively important role for labor supply considerations in shaping the response of employment to a monetary policy shock.

<sup>22</sup>Note that Moscarini and Postel-Vinay (2023) consider a sufficiently flexible model whereby job-to-job transitions show little response to a monetary policy shock, but considerable responses to other demand shocks.

**4.1. The Ins and Outs (and Everything Else) of Unemployment.** Going back to Darby, Haltiwanger and Plant (1986), an empirical literature has studied whether inflows from employment or outflows from unemployment are more important for explaining the total variation in unemployment over the business cycle. An influential paper by Shimer (2012) argues for the primacy of the outflow rate, arguing that the job-finding rate explains three-quarters of the total variation in unemployment. Although disagreements remain about the total contribution of outflows relative to inflows—see, e.g., Elsby, Michaels and Solon (2009), Fujita and Ramey (2009), and Elsby, Hobijn and Şahin (2015)—the dominant quantitative DMP modelling paradigm has largely followed the conclusion of Shimer (2012) and abstracts entirely from cyclical separations.<sup>23</sup>

We now use the accounting decomposition of the unemployment rate into labor market flows implied by equation (1) to study the contribution of each flow to unemployment in response to monetary policy shocks. Our motivation is twofold: First, analyses of unconditional variation in unemployment à la Shimer (2012) implicitly consider the impact of multiple shocks to unemployment. It is an open question whether the relative importance of job-finding and job-separation rates in response to monetary policy should be the same as their unconditional importance, given that some authors have used the latter to argue for the importance of shocks that directly interfere with the process by which workers and firms meet, including shocks to matching efficiency (e.g., Sala et al. (2012), Furlanetto and Groshenny (2016), Gagliardone and Gertler (2023)).

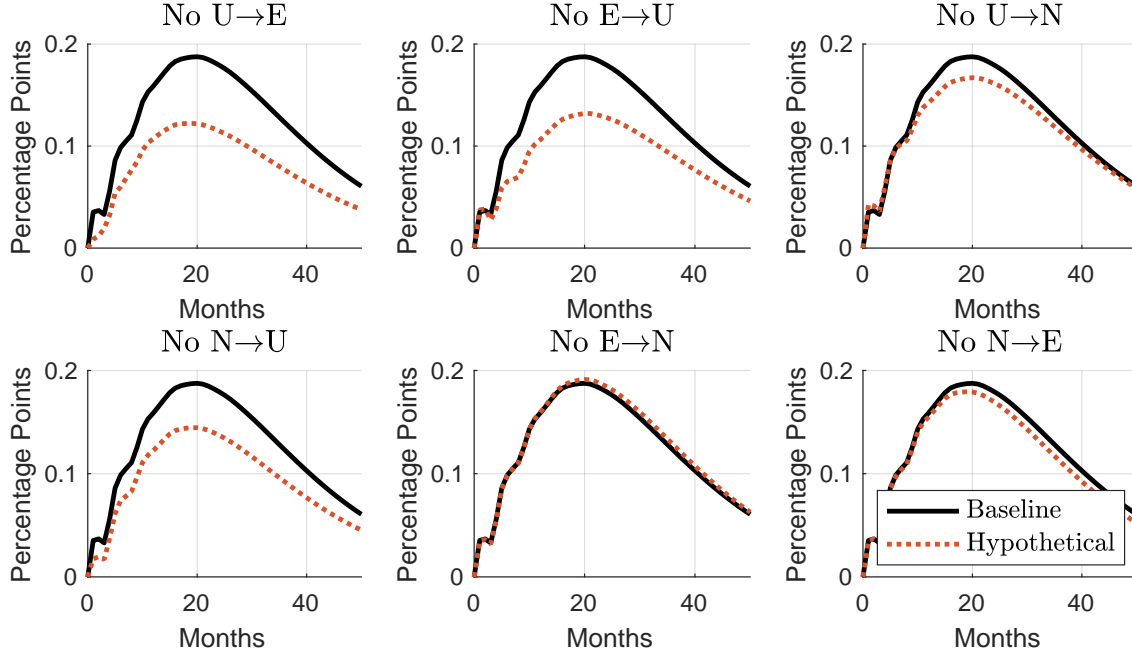
Second, the assessment of the relative importance of job-finding versus separations in determining the unconditional dynamics of unemployment is sensitive to filtering procedures, as discussed by Fujita and Ramey (2009). Insofar as our specification follows best practices from the monetary SVAR literature, our results can be seen as consistent with the methodology of a well-established paradigm.

We calculate hypothetical IRFs where we assume a given flow remains at its average level, but we take the estimated IRFs for the other flows as given. We feed the IRFs into equation (1) for each horizon  $t$ , and we use the implied stocks  $\{E_t, U_t, N_t\}$  to calculate the unemployment rate for each date  $t$ , using the relationship  $u_t = U_t/(U_t + E_t)$ . We repeat this procedure for each of the given six flows across the three distinct labor market states.

The hypothetical impulse response functions for the unemployment rate are plotted in Figure 8. The solid black lines show the IRFs for the unemployment rate estimated from our baseline VAR, while the dotted red line in each panel shows the hypothetical IRFs generated when we “turn off” the response of a given transition probability to the monetary policy surprise. The greater the distance between the counterfactual and baseline IRF, the more important is that transition probability for generating the total response of unemployment to the contractionary monetary policy shock. The subplots of Figure 8 show that the counterfactual IRFs holding the

<sup>23</sup>See, for example, Shimer (2005), Hall (2005), Hagedorn and Manovskii (2008), Hall and Milgrom (2008), Gertler and Trigari (2009), and Christiano et al. (2016). Some notable exceptions to this paradigm include Menzio and Shi (2011), Fujita and Ramey (2012), and Elsby and Michaels (2013).

FIGURE 8. The Ins and Outs of Unemployment



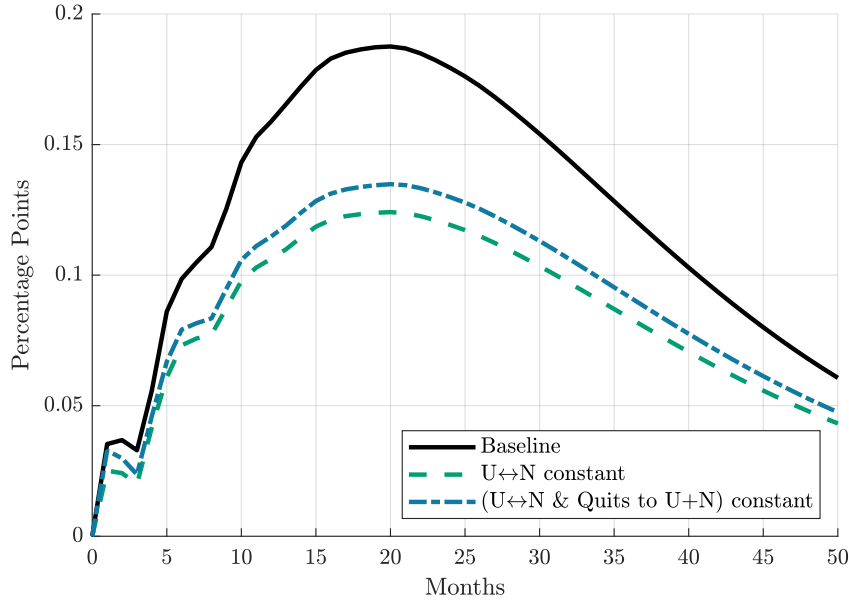
*Note:* The black solid line shows the overall response of the unemployment rate to a contractionary monetary policy shock. The red dotted lines show the response if the specified flow rate is held constant.

EU and UE responses constant reach roughly similar levels of peak unemployment: the IRF with constant UE flows reaches 65% of the baseline, whereas the IRF with constant EU flows reaches 70%.

Hence, our estimates imply that EU and UE responses to monetary policy shocks offer roughly equal contributions to the overall increase in unemployment from a monetary policy shock. These findings imply that New Keynesian models accounting for the behavior of labor market aggregates in response to monetary policy should offer some mechanism to account for the cyclicalities of involuntary separations.

Figure 8 also shows that NU and UN flows are next in importance for explaining the total response of unemployment to a monetary policy shock, while EN flows play no role. In Figure 9, we aggregate the effects of these supply-driven flows. We plot the response of unemployment in three scenarios: First, the baseline shows the response when all flows respond as estimated in our VAR. Second, we shut down the response of flows from U to N and vice versa. In the third scenario, we additionally shut down the response of quits to non-employment. The removal of  $U \leftrightarrow N$  flows lowers the response of unemployment by one third, consistent with the findings of Elsby et al. (2015). The additional removal of quits hardly changes the peak unemployment response further. These results might be interpreted as evidence that supply-driven flows, particularly quits, are relatively inconsequential for understanding the overall

FIGURE 9. Flow-Based Accounting for Unemployment



*Note:* The black solid line shows the overall response of the unemployment rate to a contractionary monetary policy shock. The green dashed line shows the response if both  $UN$  and  $NU$  rates are held constant. The blue dot-dashed line shows the response if quits to  $U$  or  $N$  are also held constant.

labor market response to a monetary policy surprise. In the next section, we focus on the response of employment and show otherwise.

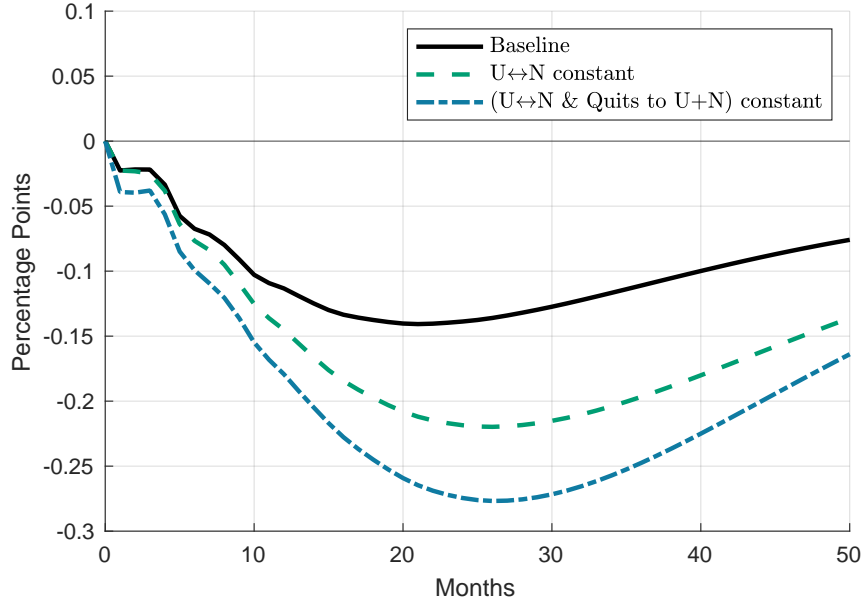
**4.2. The Labor Supply Channel of Monetary Policy.** In this section, we turn from unemployment to employment. We find that the response of flows driven by labor supply considerations plays a quantitatively important role in moderating the overall decline in employment.

Figure 10 plots the response of employment to a contractionary monetary policy shock in the same three scenarios as in Figure 9. The removal of the response of  $U \leftrightarrow N$  flows leads to a peak fall in the employment-population ratio that is almost 60% larger than in the baseline.

Why does removing  $U \leftrightarrow N$  flows have such a substantial impact on employment? Recall that, even though workers in nonparticipation and unemployment both see a reduction in the rate at which they go to employment,  $UE$  rates are substantially higher than  $NE$  rates, on average. Given that shutting down the response of  $U \leftrightarrow N$  flows implies that more individuals remain in nonparticipation, this has a large effect on the overall rate at which workers move from non-employment to employment. To our knowledge, ours is the first study to highlight the importance of  $U \leftrightarrow N$  flows to either the unconditional or conditional cyclical behavior of employment.

Next, to understand the full quantitative importance of labor supply in shaping the response of employment to a contractionary monetary policy shock, we also shut

FIGURE 10. Flow-Based Accounting for Employment



*Note:* The black solid line shows the overall response of the employment-population ratio to a contractionary monetary policy shock. The green dashed line shows the response if both UN and NU rates are held constant. The blue dot-dashed line shows the response if quits to U or N are also held constant.

down the response of quits to non-employment. In this scenario, the employment-population ratio falls by roughly an additional 40%, as we are now turning off the significant decline in quits to non-employment identified in Section 3.3. Hence, absent the contribution from the response of supply-driven labor market flows to a contractionary monetary policy surprise, the decline in the employment-population ratio nearly doubles.<sup>24</sup> In the next sections we will argue that the response of such supply-driven labor market flows is consistent with an important income effect: faced with a worsening economy and more limited budget sets, households increase their willingness to supply labor.<sup>25</sup>

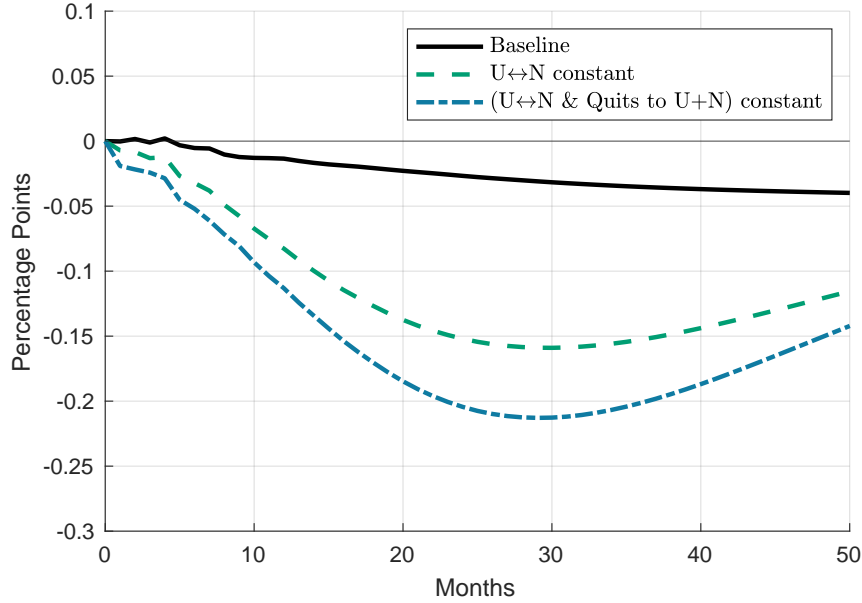
The strongly countercyclical increase in labor supply in response to a monetary policy surprise might seem odd given the procyclical response of the labor force participation rate that we estimate from our baseline IRFs. To understand how such a strong labor supply response can be consistent with a decline in the labor force participation rate, we study a similar decomposition for the labor force participation rate in Figure 11. Shutting down the response of supply-driven labor market flows

<sup>24</sup>Note here we are not including the decline in “other” separations to nonparticipation in the labor supply response. This is a conservative assumption, given that such separations, which include retirements as well as individuals that are “tired of working”, have similar cyclical properties to quits to nonparticipation and are of a similar magnitude.

<sup>25</sup>We offer validation for this interpretation in the next section, where we consider heterogeneity in the labor supply response of ex-ante distinct subgroups of workers.



FIGURE 11. Flow-Based Accounting for Participation



*Note:* The black solid line shows the overall response of the labor force participation rate to a contractionary monetary policy shock. The green dashed line shows the response if both UN and NU rates are held constant. The blue dot-dashed line shows the response if quits to U or N are also held constant.

generates a substantially larger decline in the labor force participation rate than under the baseline. The shift in the composition of workers from nonparticipation to unemployment increases the participation rate directly, but also indirectly, given that the unemployed are much more likely than nonparticipants to move to employment, and employed individuals are much less likely than the unemployed to exit the labor force.<sup>26</sup>

Note that, although labor force participation is often interpreted as a measure of labor supply at business cycle frequencies (e.g., Erceg and Levin (2014)), Figure 11 shows that the procyclical behavior of participation is accounted for by labor market flows traditionally associated with labor demand, consistent with Hobijn and Şahin’s (2021) explanation of the “participation cycle.” Indeed, we show that the response of supply-driven flows to an unanticipated monetary contraction significantly dampens the decline of labor force participation. Hence, looking towards labor force participation for insight into the behavior of labor supply at business cycle frequencies will generate misleading inference.

<sup>26</sup>Hobijn and Şahin (2021) show that that unconditional business cycle variation in labor force participation (i.e., the participation cycle) can be explained by fluctuations in EU and UE rates. Our findings indicate that EU and UE rates play a similar role in the conditional response of labor force participation to monetary policy shocks.

## 5. HETEROGENEITY IN LABOR RESPONSES TO MONETARY POLICY

The previous section shows that the labor supply increase in response to a contractionary monetary policy shock attenuates the overall decline in employment by roughly one half. While the sticky-wage New Keynesian literature typically abstracts from any such role for labor supply (as discussed by Broer et al. 2020), we have argued that such a response can naturally be understood as being driven by an income effect: in the face of a monetary contraction, households “feel poorer” and supply more labor.

Here, we study the labor supply response of lower- and higher-educated workers.<sup>27</sup> Lower-educated workers typically have fewer financial assets by which to smooth consumption. But moreover, we establish that lower-educated workers face more severe reductions in employment in response to a monetary policy contraction, due in large part to a greater increase in the probability of being laid-off. Thus, under the interpretation that the aggregate increase in labor supply to a monetary policy contraction can be understood through an income effect, we should expect a greater increase in labor supply from lower-educated workers. We show that this is indeed the case: lower-educated workers exhibit a far greater increase in labor supply in the face of a monetary policy contraction, most evident from a decrease in quits to nonparticipation.

The left column of Figure 12 shows the impulse responses of the employment-population ratio to a 25bp contractionary monetary surprise for both groups. Employment of higher-educated workers responds modestly to the contraction, reaching a maximum reduction of around  $-0.15$  percent at 20 months. In comparison, the employment reduction for lower-educated workers is far more dramatic, dropping around  $-0.30$  percent and remaining below zero even fifty months after the shock.<sup>28</sup>

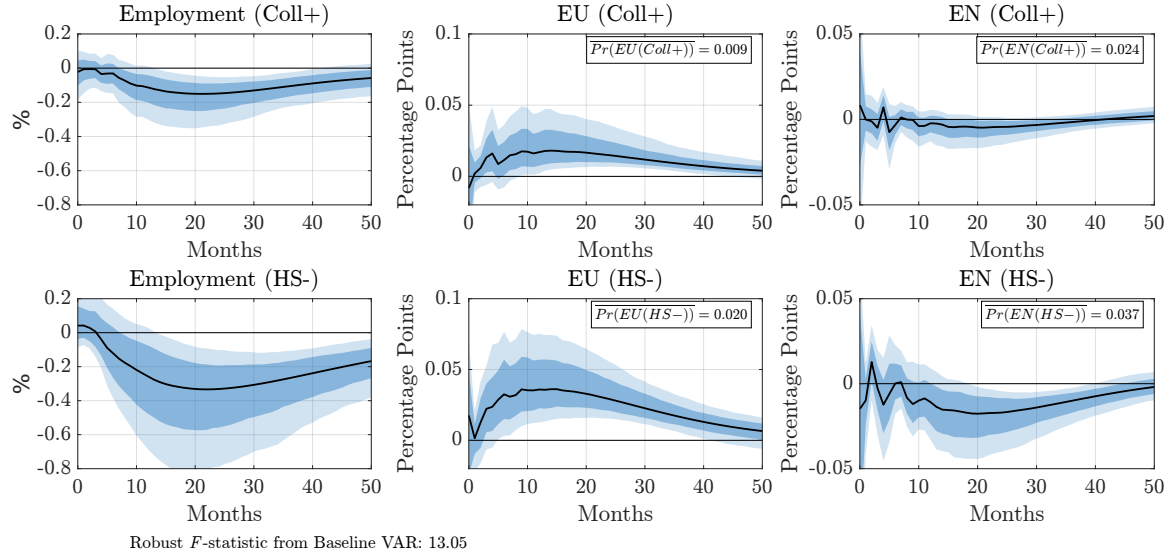
In the middle and right panels of Figure 12, we show the response of the EU and EN flow rates for each education group. This shows that the increase in employment-to-unemployment flows following a monetary contraction is substantially larger for lower-educated workers than higher-educated workers, with peak increases of around 0.04 and 0.02 percentage points, respectively. Splitting by education also shows that the decline in EN flows—which we have shown is driven by a decline in quits to non-employment—is concentrated among lower-educated workers. There is no discernible drop for higher-educated workers.<sup>29</sup> The larger increase in employment-to-unemployment flows among low-educated workers is consistent with a greater reduction in labor demand; whereas the larger decrease in quits from employment to nonparticipation is consistent with a larger increase in labor supply.

<sup>27</sup>We classify an individual as higher-educated if they have attended at least some college, whereas a worker is designated to be lower-educated if their maximum educational attainment is a high-school diploma.

<sup>28</sup>We show in the Appendix that the difference in responses of employment and labor market flows across high- and low-skill workers shown in Figure 12 is statistically significant.

<sup>29</sup>Figure C.8 of the Appendix, however, shows a labor supply response among higher-educated workers in the form of higher NU flows and lower UN flows in response to a contractionary monetary policy shock.

FIGURE 12. Responses by Education



*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 4. The top row reports results for individuals with at least some college education. The bottom row reports results for individuals with at most a high-school diploma. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Inset boxes report average transition rates. Robust  $F$ -statistic reported for baseline VAR from Figure 4. See text for details.

We see three important takeaways from these estimates: First, monetary policy shocks do not hit all workers equally. Lower-educated workers see greater employment declines from a monetary policy contraction, in part from a more responsive layoff margin. Second, labor supply responses show important differences across groups. Lower-educated workers appear to adjust their labor supply more aggressively to offset the negative employment impact of a monetary policy shock. To the extent that this supply response is driven not only by a larger increase in layoffs but also through lower asset holdings, our findings suggest that the wealth distribution helps shape the aggregate labor supply response to a monetary policy shock. Third, the greater labor supply response of workers who hold less wealth and incur more severe employment impacts from a contractionary monetary policy shock is consistent with an income effect. We consider this third point in the next section.

## 6. A SIMPLE MODEL OF COUNTERCYCLICAL LABOR SUPPLY RESPONSES TO MONETARY POLICY SHOCKS

Our empirical analysis shows a countercyclical labor supply response to a monetary policy shock: a contractionary monetary policy shock increases job-seeking behavior and diminishes the rate at which workers quit to nonparticipation. Here, we use a simple partial equilibrium search model to establish the economic plausibility of

our empirical findings. In the model, we consider a monetary policy contraction as a reduction in the job-finding rate and an increase in the marginal utility of consumption and then compute comparative statics around a steady-state.<sup>30</sup>

As we demonstrate, the model implies that a contractionary monetary policy shock has both a substitution and an income effect on participation from non-employment. By the substitution effect, a reduction in the job-finding rate reduces the return to job search, and thus workers are more likely to move from unemployment to nonparticipation to avoid the utility costs associated with actively searching for a job. However, we also document the presence of an offsetting income effect, where an increase in the marginal utility of consumption reduces the consumption-equivalent value of leisure, moving workers from nonparticipation to unemployment.

For our simple model to be consistent with the data, the income effect must dominate.<sup>31</sup> Hence, we speculate that the incorporation of frictional labor markets, a participation decision, and sufficiently strong income effects would allow the sticky-wage New Keynesian framework to account for our new empirical findings.<sup>32</sup>

**6.1. Setting.** Time is continuous with an infinite horizon. There is a unit measure of households, each of which consists of a continuum of workers who insure each other against labor market risk. Workers receive utility from consumption and leisure, have time-separable preferences, and discount the future at a constant rate  $r$ . A worker may be employed or non-employed, and takes the wage  $w$  and job-finding rate  $\lambda$  as given. The worker sacrifices some leisure to search, and enjoys no leisure at all when employed. Workers are heterogeneous in the fixed flow value of leisure  $b$  that they receive while not working. Workers draw a new flow value of leisure  $b'$  at rate  $\chi$  from a distribution  $F$  with fixed support  $[\underline{b}, \bar{b}]$ .

Define  $V_0(b)$  as the value of non-employment in consumption-equivalent units. The worker chooses whether or not to engage in active search—i.e., selects  $s \in \{0, 1\}$ . If she chooses to engage in active search, so that  $s = 1$ , she incurs a disutility cost from leisure  $\psi$ , but finds jobs at a higher rate, equal to  $\lambda$  if  $s = 1$  vs.  $(1 - \alpha)\lambda$  if  $s = 0$ , where  $\alpha \in (0, 1)$ . Thus, the annuity value of unemployment in consumption-equivalent units

<sup>30</sup>Our focus on such “indirect effects” of monetary policy are consistent with conclusions regarding the transmission of monetary policy from the heterogeneous-agent New Keynesian literature, e.g., Kaplan, Moll and Violante (2018) and Auclert, Rognlie and Straub (2020).

<sup>31</sup>We also show that the model generates a reduction in quits in response to a higher marginal utility of consumption.

<sup>32</sup>Note that the essential modeling ingredients highlighted here have been incorporated into the RBC framework in the pioneering work of Krusell et al. (2017, 2020) and are the subject of further study by Cairó, Fujita and Morales-Jiménez (2022).

can be expressed as

$$rV_0(b) = \max_{s \in \{0,1\}} \left\{ \frac{b - \psi \cdot \mathbb{I}\{s = 1\}}{\mu} + (\alpha s + (1 - \alpha))\lambda \left[ \max\{V_1(b), V_0(b)\} - V_0(b) \right] + \chi \left[ \int_{\underline{b}}^{\bar{b}} V_0(b') dF(b') - V_0(b) \right] \right\} \quad (8)$$

where  $V_1(b)$  is the consumption-equivalent value of employment of a worker with a flow value of leisure  $b$ .

Note that the flow value of leisure is scaled by the marginal utility of consumption,  $\mu$ , where the marginal utility of consumption is equalized within the representative family. Thus, when consumption drops (so that the marginal utility of consumption increases), the worker places less value on leisure. Although workers not searching from non-employment encounter jobs at a rate  $(1 - \alpha)\lambda$ , workers with a high enough value of leisure  $b/\mu$  might be unwilling to accept a job. Hence, workers receiving job offers compare the value of work against the continued value of non-employment, as seen in the max operator in the second line of equation (8).

Next, consider the annuity value of employment in consumption-equivalent units:

$$rV_1(b) = \max \left\{ rV_0(b), w + \delta[V_0(b) - V_1(b)] + \chi \left[ \int_{\underline{b}}^{\bar{b}} \max\{V_0(b'), V_1(b')\} dF(b') - V_1(b) \right] \right\} \quad (9)$$

The only decision of the employed worker is whether to quit her job.

**6.2. Searching, Accepting a Job, and Quitting.** Non-employed workers make two decisions: whether or not to search, and whether or not to accept a job. Employed workers make a single decision: whether or not to quit to non-employment.

In the Appendix, we show that the value of employment and non-employment is strictly increasing in the flow value of leisure  $b$ . We also show that the surplus from employment,  $V_1(b) - V_0(b)$ , is decreasing in  $b$ . We use these results to establish the existence of unique thresholds  $b^s$  and  $b^q$ , with  $\underline{b} < b^s < b^q < \bar{b}$ , such that non-employed workers strictly prefer to search for a job when  $b < b^s$ , are indifferent between searching and not searching when  $b = b^s$ , and strictly prefer to not search when  $b > b^s$ . Similarly, non-employed workers strictly prefer accepting a job when  $b < b^q$ , are indifferent between accepting a job and not accepting when  $b = b^q$ , and strictly prefer not accepting a job when  $b > b^q$ . Finally, employed workers are indifferent between remaining employed and quitting a job when  $b = b^q$ , strictly prefer to remain employed when  $b < b^q$  and strictly prefer to quit to non-employment when  $b > b^q$ .

We establish several useful results, beginning with Corollary 1:

**Corollary 1** (Active search threshold). *Define  $V_0^s(b)$  as the value of a non-employed worker who optimally engages in active search. Define  $V_0^{ns}(b)$  as the value of a non-employed worker who optimally does not engage in active search, but accepts job offers*

from non-employment. Then, the threshold  $b^s$  such that  $V_0^s(b^s) = V_0^{ns}(b^s)$  satisfies

$$\frac{\psi}{\mu} = \alpha\lambda (V_1(b^s) - V_0(b^s)) \quad (10)$$

*Proof.* See Appendix D.  $\square$

Equation (10) defines the flow value of leisure  $b^s$  for which a non-employed worker is indifferent between not actively searching and actively searching. The left side of equation (10) expresses the leisure cost of active search  $\psi$  in consumption units, while the right side expresses the benefit of search: the non-employed worker finds jobs at rate  $\lambda$  vs. rate  $(1 - \alpha)\lambda$  when not actively searching. Thus,  $\alpha\lambda (V_1(b^s) - V_0(b^s))$  reflects the additional capital gains associated with the higher rate of job offers for a worker engaged in active search.

We also establish Corollary 2:

**Corollary 2** (Quit threshold). *Define  $b^q$  as the threshold flow value of leisure at which a non-employed worker is indifferent between accepting a job offer or remaining non-employed; or equivalently, the threshold value of leisure at which an employed worker is indifferent between remaining employed or quitting to non-employment. Then, the threshold  $b^q$  satisfies*

$$\frac{b^q}{\mu} = w + \chi \int_{\underline{b}}^{b^q} (V_1(b') - V_0(b')) dF(b') \quad (11)$$

*Proof.* See Appendix D.  $\square$

Note that the quitting/accepting threshold  $b^q$  in consumption-equivalent units is higher than the wage due to an option value from employment. The option value reflects that a worker may be hit by a preference shock that shifts her value of leisure below  $b^q$ , in which case she will prefer employment.

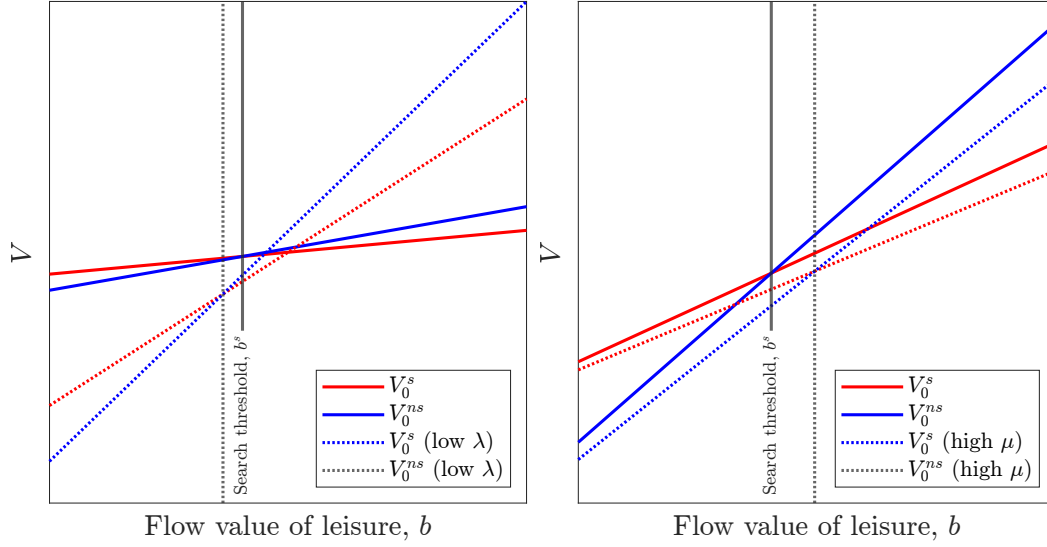
**6.3. Comparative Statics.** We study a contractionary monetary policy shock within our simple model by studying the comparative statics of the stationary model around a steady state where  $\chi = 0$ . We consider two sources of variation: a change in the aggregate job-finding rate,  $\lambda$ , and a change in the marginal utility of consumption,  $\mu$ .<sup>33</sup>

**Proposition 1** (Substitution and income effects). *Consider a decrease in the aggregate component of the job-finding rate  $\lambda$  and an increase in the marginal utility of consumption  $\mu$ . A decrease in the job-finding rate decreases the search threshold  $b^s$ , and thus induces less workers in non-employment to search; whereas an increase in the marginal utility of consumption does the opposite.*

*Proof.* See Appendix D.  $\square$

<sup>33</sup>We could also consider the response of worker labor supply to changes in wages; however, as we show in Figure C.5, the response of wages to a monetary policy shock is an order of magnitude smaller than that of labor market aggregates such as unemployment.

FIGURE 13. The Substitution and Income Effects of a Monetary Policy Shock



*Note:* Non-employed with flow value of leisure  $b$  less than the threshold  $b^s$  engage in active search. In the left panel, a decrease in the aggregate component of job-finding rate  $\lambda$  decreases  $b^s$  and thus decreases the fraction of workers in non-employment engaged in active search. In the right panel, an increase in the marginal utility of consumption  $\mu$  increases  $b^s$  and thus increases the fraction of workers in non-employment engaged in active search.

To see the logic of the proof, see from the Appendix that, if  $\chi = 0$ , equation (10) can be written more simply as

$$\underbrace{\left(\frac{\psi}{\mu}\right)}_{\text{Cost of active search (in consumption units)}} = \alpha \lambda \underbrace{\left(\frac{w - \frac{b^s - \psi}{\mu}}{r + \delta + \lambda}\right)}_{\text{Additional capital gains from active search}} \quad (12)$$

where the term in parentheses on the right side of equation (12) reflects the steady-state surplus when  $\chi = 0$ . Thus, the left side of the equation reflects the cost of search, while the right side reflects the benefit. As shown in the left panel of Figure 13, the reduction in  $\lambda$  decreases the rate at which workers find jobs, and thus the relative benefit of search decreases. This represents a pure substitution effect, and so  $b^s$  will thereby decrease and fewer workers will search.

Conversely, suppose that the marginal utility of consumption  $\mu$  increases. In this case, not only does the consumption-equivalent cost of search  $\psi/\mu$  decrease, but the flow value of leisure  $(b^s - \psi)/\mu$  declines, increasing the flow surplus of employment.<sup>34</sup>

<sup>34</sup>Note that such an income effect can be understood through Chodorow-Reich and Karabarbounis's (2016) notion of the "opportunity cost of leisure," which they estimate to be unconditionally procyclical. Our evidence suggests that the opportunity cost of leisure should be similarly procyclical in response to monetary policy shocks.

This represents an income effect, pushing  $b^s$  up so that a larger mass of non-employed workers will be engaged in search, as shown in the right panel of Figure 13. In contrast, shocks to  $\mu$  and  $\lambda$  move the quit threshold weakly in the same direction, as discussed in the Appendix.<sup>35</sup>

Given a contractionary monetary policy shock that decreases the job-finding rate  $\lambda$  and increases the marginal utility of consumption  $\mu$ , the substitution effect will drive the fraction of workers searching from non-employment down, whereas the income effect will drive the fraction of workers searching from non-employment up. Under our estimates of increasing NU flows and decreasing UN flows with respect to a contractionary monetary policy shock, our simple model suggests that the income effect should not only be present, but also sufficiently strong to offset the counteracting substitution effect.

A recent literature including Nekarda and Ramey (2020) and Auclert et al. (2021) has argued for the inclusion of sticky wages into the standard New Keynesian framework. As discussed by Broer et al. (2020), however, the inclusion of sticky wages into an NK model with a neoclassical labor market-clearing condition precludes a role for income effects on labor supply in determining aggregate employment dynamics, contrary to the estimates shown here. Moreover, workers may be required to provide labor against their own will under such a framework, as documented by Huo and Ríos-Rull (2020). In contrast, under a search framework, income effects can be an important ingredient in explaining the response of labor market flows to a monetary policy shock even if wages are held fixed, as shown here. By additionally allowing for endogenous quits and layoffs, such a model maintains the principle of free exchange, avoiding the criticism of Huo and Ríos-Rull (2020).

## 7. CONCLUSION

This paper offers new empirical evidence of a sizeable labor supply response to monetary policy. Using high-frequency identified monetary policy shocks from FOMC announcements and Fed Chair speeches, we show that a contractionary monetary policy shock generates quantitatively important increases in labor supply by decreasing the rate at which workers quit jobs to non-employment and stimulating job-seeking behavior among the non-employed. Thus, the decline in labor demand from a monetary policy tightening is partially offset by an increase in labor supply. We show that if the response of supply-driven labor market flows is held fixed, the overall procyclical response of employment to monetary policy would be roughly twice as large.

An empirical contribution of our paper is to highlight the large and cyclical role of quits to nonparticipation. Previous research has shown that the vast majority of separations from employment to unemployment are due to layoffs rather than quits. We have shown that the opposite is true for separations from employment to nonparticipation. Our flow-based accounting framework reveals that, in response to a contractionary monetary policy shock, the decline in quits to nonparticipation is

<sup>35</sup>Note that for  $\chi = 0$ , the quit threshold is unaffected by changes in  $\lambda$ .



roughly as important as the increase in job-seeking behavior among the non-employed in dampening the overall decline in employment.

Given the importance of supply-driven flows revealed by our estimates, models intended to generate a realistic employment response to monetary policy may require a greater role for labor supply than currently considered in the New Keynesian literature. This may be especially true for models with an explicit role for heterogeneity à la Kaplan, Moll and Violante (2018). In a partial equilibrium setting, we have shown that a model with frictional labor markets, an active participation decision, and sufficiently strong income effects is likely to be consistent with our empirical findings. We believe that incorporating such features into a fully-fledged New Keynesian model is an important topic for future research.

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## APPENDIX A. ADDITIONAL CPS MEASUREMENT DETAILS

**A.1. Quits versus Layoffs.** In order to understand the underlying drivers of flows from employment to non-employment, we decompose EU and EN flows into three components: quits, layoffs and other separations. We interpret quits as reflecting labor supply considerations and layoffs as being driven by labor demand.

The decomposition of EU flows is the more straightforward. Unemployed individuals in the CPS are asked their reason for unemployment. We label an EU transition as a quit if the reason for unemployment is “job leaver” and as a layoff if the reason for unemployment is “job loser/on layoff”, “other job loser” or “temporary job ended”.<sup>36</sup> The remaining EU transitions, we label as other separations.<sup>37</sup>

The decomposition of EN flows is slightly more involved. A subset of individuals that are out of the labor force are asked the reason that they left their last job. However, the sample of such individuals has changed over time. Since 1994, this question is asked to individuals in the outgoing rotation group that are: (1) not in the labor force, (2) neither retired nor disabled and (3) who report having worked in the past 12 months. Prior to 1994 this question was asked to all individuals not in the labor force who reported having worked in the past five years. The possible answers to the question also changed slightly beginning in 1994.

To create a consistent series, we restrict our attention to individuals who report having worked in the past 12 months.<sup>38</sup> We label an EN transition as a quit if the reason for leaving the job is “personal, family or school” or “unsatisfactory work arrangements”.<sup>39</sup> We label an EN transition as a layoff if the reason for leaving the job is “slack work or business conditions”. We label all remaining EN transitions as other separations.<sup>40</sup> After 1994 we assume that individuals who make an EN transition and either report being retired or disabled would have given this as their reason for leaving their job had they been asked the question. Consequently, such transitions are defined as neither quits nor layoffs. Finally, as our sample is only ever a fraction of all EN transitions, in all periods we calculate the share of EN transitions in each classification and then multiply this by the overall EN transition rate to complete our

<sup>36</sup>Ideally we would not label the end of a temporary job as a layoff. However, between 1989 and 1993 the CPS did not include “temporary job ended” as an option in the survey. It appears that during this period such transitions were classified as either “job loser/on layoff” or “other job loser”. Thus, in order to avoid breaks in the series we must group these codes together. This has little effect on our results, as “temporary job ended” is only given as the reason for around 10% of EU transitions in periods when it is available.

<sup>37</sup>These are transitions where the reason for unemployment is “re-entrant” or “new entrant”. Such transitions account for 15-20% of all EU transitions.

<sup>38</sup>In principle, all individuals that make EN transitions should report having worked in the past 12 months. In practice, many do not. One possible explanation is classification error. For example, Abowd and Zellner (1985) report that slightly more than 2 percent of individuals classified as “employed” have their employment status determined as “unemployed” or “non-participant” upon re-interview.

<sup>39</sup>These are the possible answers from before 1994. After 1994 we define such transitions analogously.

<sup>40</sup>Other EN separations include retirements, disabilities, and the end of temporary seasonal or non-seasonal jobs.

decomposition. This gives us the time series of our decomposed EU and EN transition rates, as shown in Figure 2.

**A.2. “Intensive Margin” of Labor Supply.** Our measure of the intensive margin for unemployed workers is the number of distinct job search methods that they report. The re-design of the CPS in 1994 complicates the construction of a consistent series for this measure, as it increased the number of possible job search methods from 6 to 12. Consequently, we allow for 5 possible methods of active search: “contacted public employment agency”, “contacted private employment agency”, “contacted friends or relatives”, “contacted employer directly/interview” and “other active”. We then group the answers from pre- and post-1994 into these 5 categories and calculate the average number of search methods among unemployed individuals.<sup>41</sup>

Our measure of the intensive margin for non-participants is the fraction of such individuals who report that they want a job. Before 1994, non-participants were only asked whether they wanted a job in the outgoing rotation group. The possible answers were “Yes”, “Maybe, it depends”, “No”, or “Don’t know”. From 1994 this question was asked to all non-participants and the possible answers were changed to “Yes, or maybe, it depends”, “No”, “Retired”, “Disabled”, or “Unable to work”. Given the change in possible answers, we group “Yes” and “Maybe, it depends” as “Yes” and all other answers as “No”. This gives us a consistent series over time that displays no break at the 1994 re-design.

## APPENDIX B. THE RESPONSE OF OTHER VARIABLES

**B.1. Job-to-Job Transitions.** Beginning with Faberman and Justiniano (2015), an empirical literature has documented that a high unconditional correlation between quits and wage growth. While Faberman and Justiniano interpret quits to be job-to-job transitions, subsequent papers directly measure job-to-job transitions and document a robust unconditional correlation between job-to-job transitions with various measure of wage growth, e.g., Moscarini and Postel-Vinay (2016) and Karahan et al. (2017).

Thus, a recent literature has augmented the New Keynesian model with Bertrand wage competition over workers, à la Cahuc et al. (2006). Under the “offer-matching theory of inflation,” e.g., Birinci et al. (2022), Moscarini and Postel-Vinay (2023), and Faccini and Melosi (2023), competition between firms over workers bids up wages and increases marginal costs. The offer-matching theory implies the rate of job-to-job changes to be an important measure of labor market slack: a contractionary monetary policy shock should decrease inflation in part by reducing the rate of job-to-job transitions, and more importantly, the rate at which workers meet potential employers that allow them to bid up their wages at their current job. Thus, the theory

<sup>41</sup>In principle, “placed or answered ads” is a sixth method that is included both before and after 1994. However, we have found that the number of individuals reporting this method dropped sharply after 1994. This is likely explained by the introduction of “Sent out resumes/filled out applications” as a possible search method at this time.



implies that a contractionary monetary policy surprise should generate a decline in job-to-job transitions.

To study the offer-matching theory of inflation, we estimate the IRF for the rate of job-to-job transitions in response to a contractionary monetary policy surprise. We consider two measures of job-to-job transitions: one due to Fallick and Fleischman (2004), and another due to Fujita et al. (2020). The estimated IRFs are plotted in Figure C.1. Note, both measures are only available since 1995. Neither measure of job-to-job transitions shows any significant response to a contractionary monetary policy shock.

Taken at face value, the estimated IRFs might appear inconsistent with the offer-matching theory of inflation, as we cannot reject a null response of job-to-job transitions to a contractionary monetary policy shock. We speculate that the flat IRFs of job-to-job transitions might in part reflect a problem of measurement: neither the Fallick and Fleischman (2004) nor the Fujita et al. (2020) measures of job-to-job transitions condition on whether or not workers making job-to-job transitions are moving to better-paying jobs. Tjaden and Wellschmied (2014) document that a considerable portion of workers making job-to-job transitions move to lower-paying jobs, perhaps to avoid an involuntary layoff to unemployment. Gertler et al. (2020) document that the fraction of workers making job-to-job transitions associated with an improvement in wages is highly procyclical. Thus, it is possible that a series measuring job-to-job changes to higher-paying jobs might offer a more robust series by which to assess the offer-matching theory of inflation.<sup>42</sup>

**B.2. Vacancies.** As established in Section 3.2, a contractionary monetary policy surprise increases unemployment via both demand and supply channels. The ensuing increase in unemployment is sustained in part through a reduction in the rate at which workers move from unemployment to employment, as shown in Figure 5. All else equal, any increase in unemployment should reduce the rate at which workers from non-employment find jobs.

However, a full understanding of the response of UE and NE rates to a monetary policy surprise requires an analysis of vacancy posting by firms. Figure C.2 shows the IRF of vacancies  $v$  in response to a contractionary monetary policy surprise. Vacancies show a gradual decline, reaching a trough at around 15 months. To the extent that the process by which workers and vacancies match to create jobs can be understood through a matching function, a decline in vacancies leads to a decline in the probability that a worker finds a job from unemployment. Thus, UE and NE rates fall.

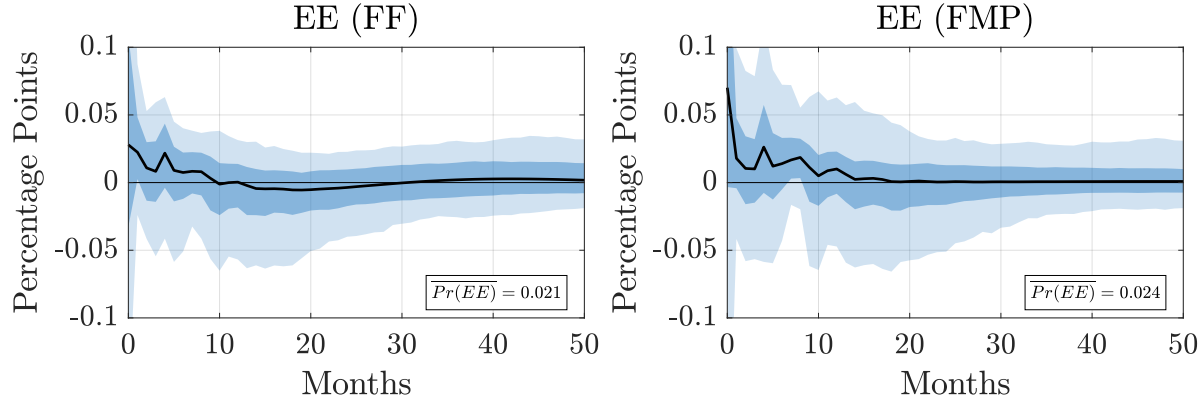
**B.3. Wages.** In Section 3.3 we interpret the differential evolution of quits and layoffs to a monetary policy shock as being evidence in favor of wage stickiness. Here we directly estimate the response of wage growth to monetary policy shocks. Figure C.5

<sup>42</sup>Another feature of the job-to-job transitions data is that it is only available after the re-design of the CPS in 1994. However, we do not believe that this short sample is responsible for the estimated non-response of job-to-job transitions: if we restrict Figure 5 to the same shorter sample the estimated responses are largely unchanged, albeit with larger confidence intervals.

plots the response of within-individual year-over-year wage growth relative to year-over-year changes in the log unemployment rate. In nominal terms, year-over-year within-individual log wage growth does not decline until ten months into the monetary contraction, reaching a trough of around  $-0.08$  percentage points at around 30 months after the monetary policy surprise. In real terms, within-individual year-over-year log wage growth reaches a trough of  $-0.1$  percentage points after around 32 months, at which point it begins its recovery. The response of year-over-year log unemployment, however, is far more dramatic, immediately rising to a peak of one percentage point 10 months after the monetary policy shock.

## APPENDIX C. ADDITIONAL FIGURES

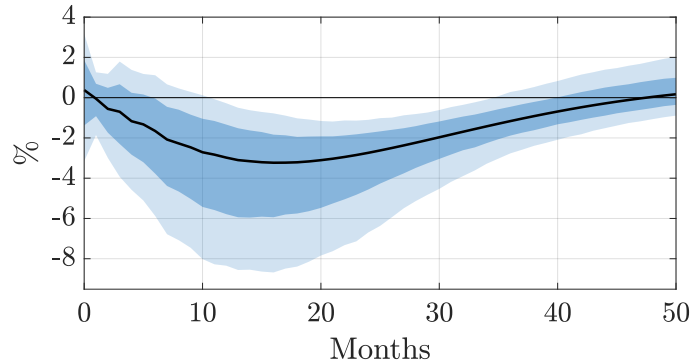
FIGURE C.1. Response of Job-to-Job Transitions



Robust  $F$ -statistic from Baseline VAR: 5.44

*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given labor market flow variable to the baseline VAR from Figure 4. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. The left panel uses the job-to-job transition rate of Fallick and Fleischman (2004) while the right panel uses that of Fujita et al. (2020). Inset boxes report average transition rates. Robust  $F$ -statistic reported for baseline VAR from Figure 4, estimated since 1995 when the job-to-job change series first becomes available. See text for details.

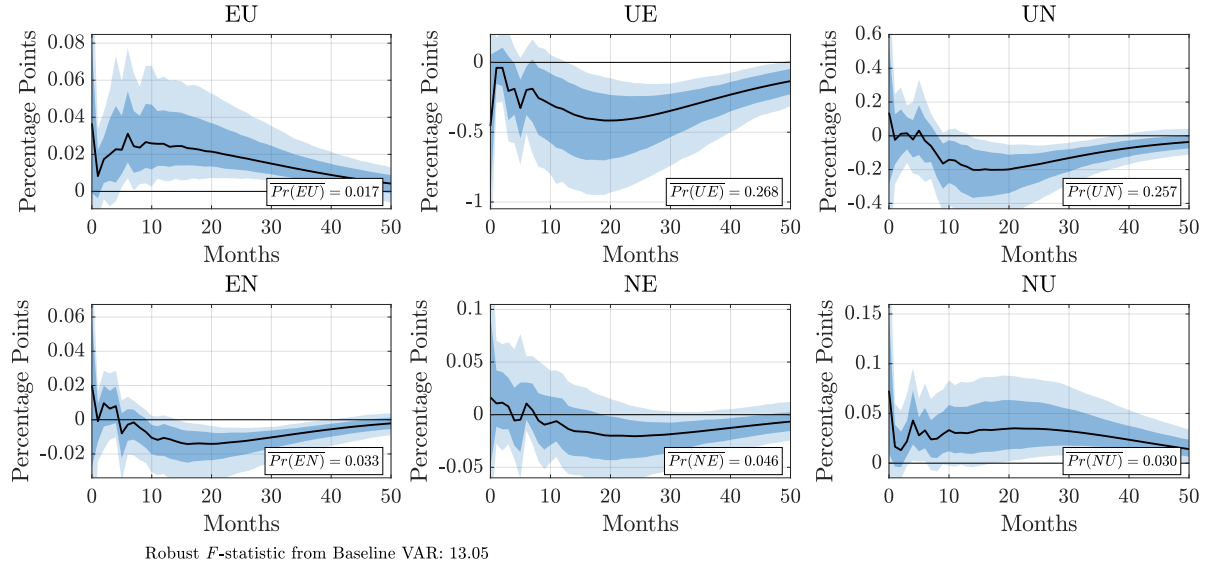
FIGURE C.2. Response of Vacancies



Robust  $F$ -statistic from Baseline VAR: 13.05

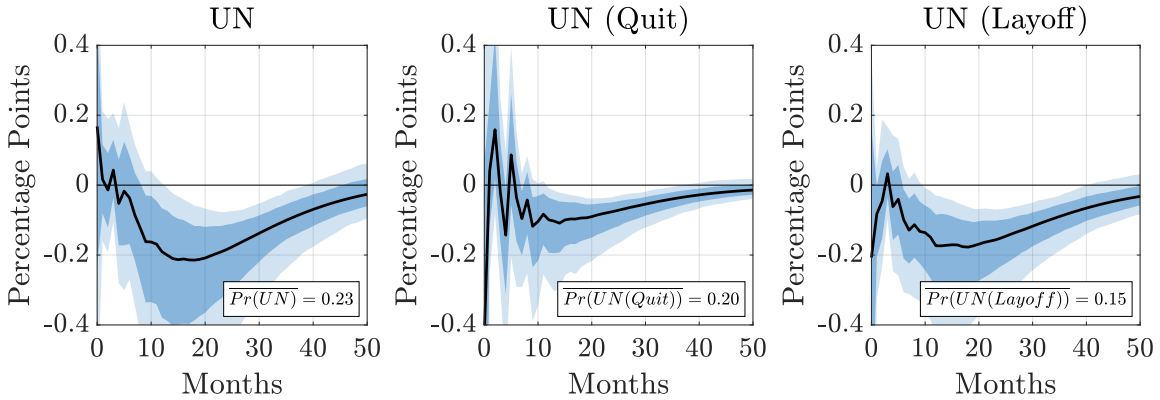
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the log of the number of vacancies to the baseline VAR from Figure 4. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. We measure vacancies using the extended help-wanted index of Barnichon (2010). Robust  $F$ -statistic reported for baseline VAR from Figure 4. See text for details.

FIGURE C.3. Response of Labor Market Flows (Composition Adjusted)



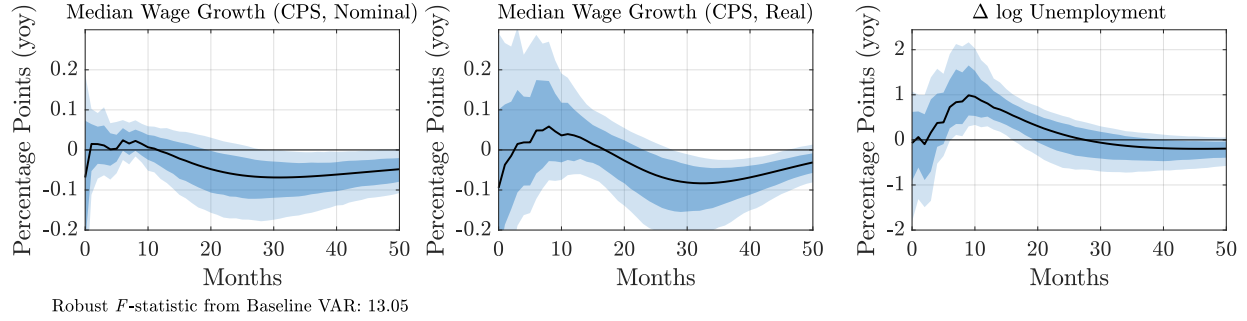
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 4. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. We construct composition-adjusted flow rates holding fixed shares by age, gender and education, as in Table 5 of Elsby, Hobijn and Şahin (2015). The responses of the composition-adjusted IRFs for labor market flows are similar to those from our baseline, in Figure 5. Inset boxes report average transition rates. Robust  $F$ -statistic reported for baseline VAR from Figure 4.

FIGURE C.4. Response of UN Flows by Reason for Unemployment



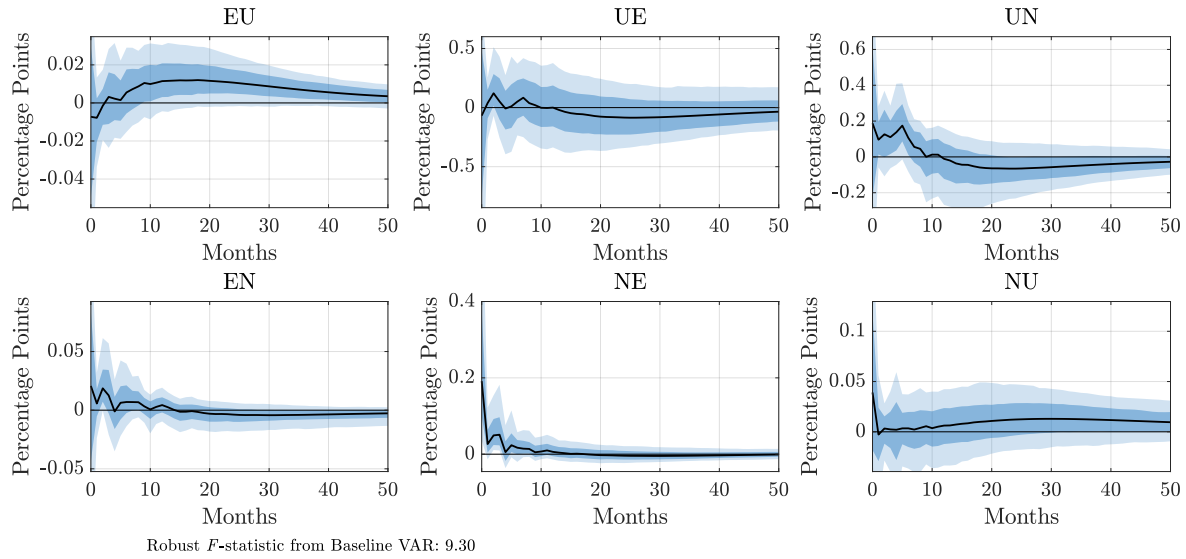
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 4. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. We compute separate IRFs for UN flows by reason for unemployment. Robust  $F$ -statistic reported for baseline VAR from Figure 4.

FIGURE C.5. Responses of Wages and Unemployment



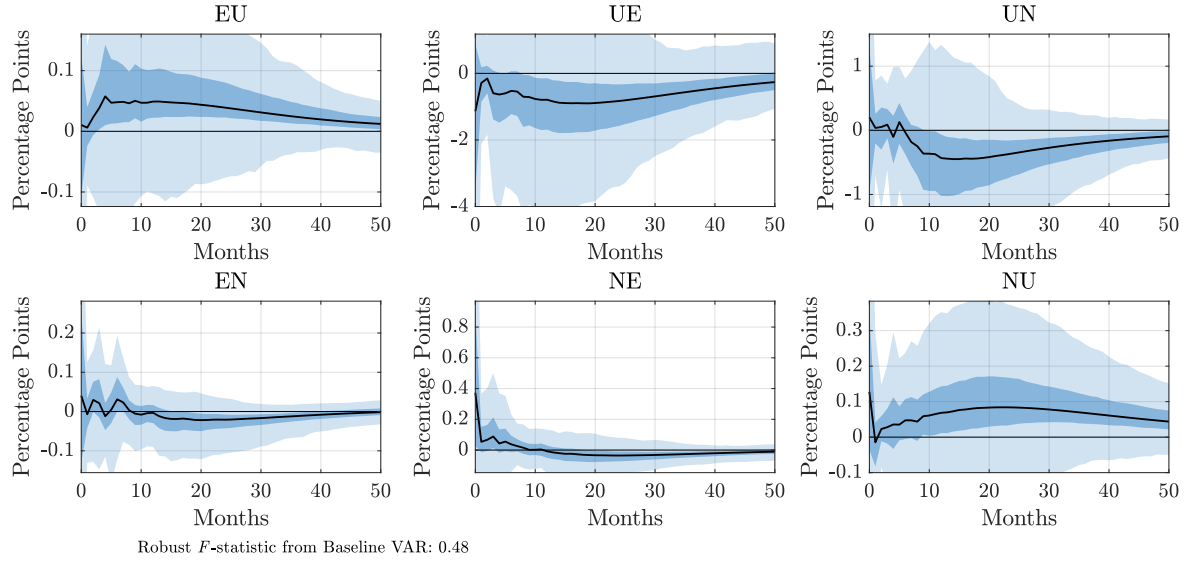
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 4. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Annual (hourly) wage growth is calculated using employed individuals in the outgoing rotation groups of the CPS. Robust  $F$ -statistic reported for baseline VAR from Figure 4.

FIGURE C.6. Labor Market Flows: Non-Orthogonalized Shocks, No Chair Speeches



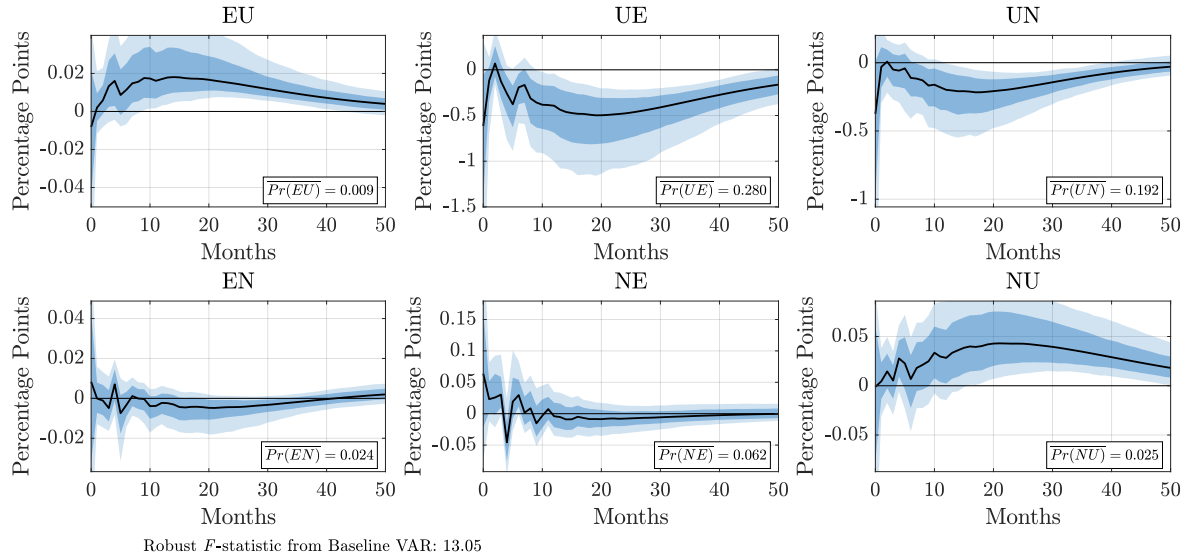
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 4, using only FOMC announcements for our monetary policy shocks, without orthogonalizing as in Bauer and Swanson (2023a,b). Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Robust  $F$ -statistic reported for baseline VAR using non-orthogonalized shocks without Chair speeches.

FIGURE C.7. Labor Market Flows: Orthogonalized Shocks, No Chair Speeches



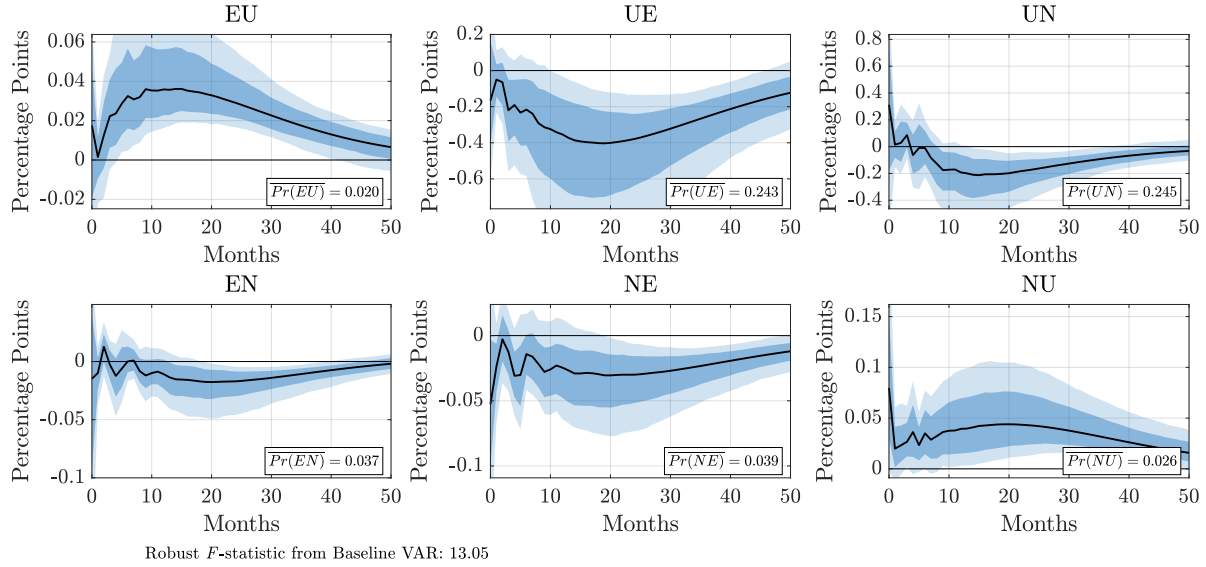
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 4, using only FOMC announcements for our monetary policy shocks, orthogonalized as in Bauer and Swanson (2023a,b). Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Robust  $F$ -statistic reported for baseline VAR using orthogonalized shocks without Chair speeches.

FIGURE C.8. Labor Market Flows: Higher-educated



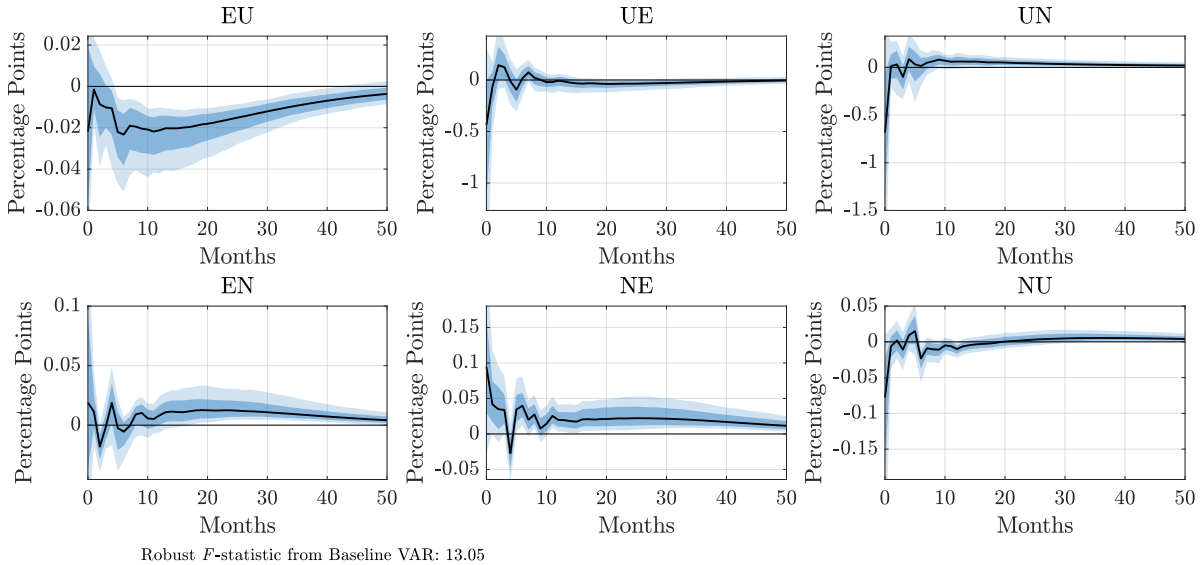
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 4. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Inset boxes report average transition rates. Robust  $F$ -statistic reported for baseline VAR from Figure 4.

FIGURE C.9. Labor Market Flows: Lower-educated



*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 4. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Inset boxes report average transition rates. Robust  $F$ -statistic reported for baseline VAR from Figure 4.

FIGURE C.10. Labor Market Flows: Higher-educated minus lower-educated



*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 4. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Robust  $F$ -statistic reported for baseline VAR from Figure 4.

## APPENDIX D. MODEL APPENDIX

Using equations (8) and (9) for the values of non-employment and employment, write the worker surplus  $V_1(b) - V_0(b)$  as

$$V_1(b) - V_0(b) = \frac{w - \frac{b - \mathbb{I}\{s=1\} \cdot \psi}{\mu} + \chi \cdot \int_{\underline{b}}^{\bar{b}} (\max \{V_1(b'), V_0(b')\} - V_0(b')) dF(b')}{r + \delta + [(1 - \alpha) + \alpha \cdot \mathbb{I}\{s = 1\}] \cdot \lambda + \chi}$$

Then, taking  $V_0^s$  as the value of non-employment when searching ( $s = 1$ ) is optimal and  $V_0^{ns}$  as the value of non-employment when not searching ( $s = 0$ ) is optimal, write

$$V_1(b) - V_0^s(b) = \frac{w - \frac{b - \psi}{\mu} + \chi \cdot \int_{\underline{b}}^{\bar{b}} (\max \{V_1(b'), V_0(b')\} - V_0(b')) dF(b')}{r + \delta + \lambda + \chi}, \quad (\text{D.1})$$

and

$$V_1(b) - V_0^{ns}(b) = \frac{w - \frac{b}{\mu} + \chi \cdot \int_{\underline{b}}^{\bar{b}} (\max \{V_1(b'), V_0(b')\} - V_0(b')) dF(b')}{r + \delta + (1 - \alpha) \cdot \lambda + \chi} \quad (\text{D.2})$$

Finally, define  $V_0^{na}$  to be the value of non-employment when not accepting a job is optimal, i.e.,  $V_0^s = \max \{V_0^s, V_0^{ns}\}$  so that

$$V_1(b) - V_0^{na}(b) = \frac{w - \frac{b}{\mu} + \chi \cdot \int_{\underline{b}}^{\bar{b}} (\max \{V_1(b'), V_0(b')\} - V_0(b')) dF(b')}{r + \delta + \chi} \quad (\text{D.3})$$

Thus,

$$V_1(b) - V_0(b) = \max \{V_1(b) - V_0^s(b), V_1(b) - V_0^{ns}(b), V_1(b) - V_0^{na}(b)\} \quad (\text{D.4})$$

Clearly,  $V_1(b) - V_0(b)$  is strictly decreasing in  $b$ . Then, it is easy to see that  $V_0(b)$  is strictly increasing in  $b$ . Given appropriate assumptions about the support  $[\underline{b}, \bar{b}]$ ,  $\exists b^q \in (\underline{b}, \bar{b})$  s.t.  $V_1(b^q) - V_0^{ns}(b^q) = 0$  and  $b^s \in (\underline{b}, \bar{b})$  s.t.  $V_0^s(b^s) - V_0^{ns}(b^s) = 0$ .<sup>43</sup> Solve for  $b^s$  such that  $V_0^{ns}(b^s) = V_0^s(b^s)$ :

$$\frac{\psi}{\mu} = \alpha \cdot \lambda (V_1(b^s) - V_0^s(b^s)) \quad (\text{D.5})$$

Then, solve for  $b^q$  such that  $V_0^{ns}(b^q) = V_1(b^q)$ :

$$b^q = \mu \left( w + \chi \int_{\underline{b}}^{b^q} (V_1(b') - V_0(b')) dF(b') \right) \quad (\text{D.6})$$

Corollaries 1 and 2 follow.

To prove Proposition 1, set  $\chi = 0$ , substitute equation (D.1) into (D.5), and then simplify to obtain (12). Solving for  $b^s$ , we obtain

$$b^s = \mu w - \frac{(\rho + \delta + (1 - \alpha)\lambda)\psi}{\alpha\lambda} \quad (\text{D.7})$$

<sup>43</sup>Note,  $b^s < b^q$ ; otherwise, agents would make strictly positive gains from not searching.



Take derivatives with respect to  $\mu$  and  $\lambda$ :

$$\frac{\partial b^s}{\partial \mu} = w \quad (\text{D.8})$$

$$\frac{\partial b^s}{\partial \lambda} = \frac{(\rho + \delta)\psi}{\alpha\lambda^2} \quad (\text{D.9})$$

Both  $\partial b^s/\partial \mu$  and  $\partial b^s/\partial \lambda$  are strictly positive.

Recall, non-employed workers with  $b \in [\underline{b}, b^s]$  engage in active search. We associated a contractionary monetary policy shock with a decline in the aggregate job-finding probability  $\lambda$  and an increase in the marginal utility of consumption  $\mu$ . Thus, a contractionary monetary policy shock *decreases* participation through the decline on the job-finding probability  $\lambda$ , operating through a substitution effect; and *increases* participation through the increase in the marginal utility of consumption  $\mu$ , operating through an income effect.

Finally, evaluating equation (11) at  $\chi = 0$ , an increase in the marginal utility of consumption will increase the quit threshold  $b^q$ , thereby reducing the mass of employed workers in  $[b^q, \bar{b}]$  who will optimally quit from their job; whereas  $b^q$  does not respond to changes in the job finding rate. Note, however, that the surplus  $V_1(b) - V_0(b)$  is decreasing in the job finding rate for  $b \in [\underline{b}, b^q]$ . Thus, if  $\chi > 0$ ,  $b^q$  will be increasing in  $\lambda$  through second term on the right side of (11) reflecting the option value of employment. This is seen in Figure 13, where we do not restrict  $\chi$  to be equal to zero.