

# 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 evidence 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, and non-employed individuals increase their job-seeking behavior. Holding such 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 (NK) 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 consistent with a substantial labor supply response to monetary policy. We begin by identifying

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<sup>1</sup>Christiano (2011), Broer et al. (2020) and Wolf (2023) offer detailed discussions of this property of the sticky-wage NK model. See also the discussion below.

labor market flows (and components of flows) that are plausibly driven by labor supply considerations. While the response of all labor market flows can be thought of as being determined in general equilibrium, certain labor market flows are more directly reflective of labor supply insofar as they are initiated by the worker. Thus, we classify flows from unemployment (U) to nonparticipation (N) and vice versa as supply-driven, given that such flows occur when an individual decides to stop or start searching actively for work. Similarly, we classify quits to non-employment as supply-driven, given that these are typically worker-initiated separations.<sup>2</sup> Indeed, 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 response of labor market flows 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 the standard interpretation of 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 a significant reduction in quits from employment to nonparticipation. 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.<sup>5</sup>

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<sup>2</sup>Our designation of supply-driven flows also accords with theoretical models, where such flows exist due to the presence of a labor supply or participation decision, e.g., Krusell et al. (2017) and Alves and Violante (2023). In these models, such flows are affected by labor supply considerations, such as income effects, as well as by the equilibrium movements in other labor market flows, such as the rate at which unemployed individuals move to employment.

<sup>3</sup>We use the terminology “flows” and “transition probabilities” interchangeably throughout.

<sup>4</sup>We find additional and complementary evidence of labor supply increasing after a contractionary monetary policy shock on the intensive margin of job search: nonparticipants are more likely to report that they want to work, while unemployed individuals use more search methods to find a job.

<sup>5</sup>Such an income effect is the key driver of the procyclicality of the “opportunity cost of leisure,” in Chodorow-Reich and Karabarbounis (2016).

To quantify the importance of this estimated response of supply-driven flows, we build upon the methods of Shimer (2012) and Elsby, Hobijn and Şahin (2015). We construct hypothetical impulse responses of employment holding candidate labor market flows constant at their steady-state value, allowing us to quantify the contribution of such flows to the total response of employment. 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 interpret this as evidence of a quantitatively important role for supply-driven labor flows in shaping the overall response of employment to a monetary policy shock.

We then explore heterogeneity in labor supply responses to an unanticipated monetary contraction. We show that cyclical changes in the composition of labor market states plays only a limited role in explaining the responses of supply-driven labor market flows to monetary policy shocks, implying that the estimated response of these flows is largely driven by variation at the individual level. This finding, however, does not preclude different labor market responses across different subgroups of workers: indeed, we document evidence consistent with considerably larger increases in labor supply among lower-educated workers. We argue that this finding offers further validation for the role for income effects in shaping the labor market response to a contractionary monetary policy shock.

Finally, we formalize our interpretation for the importance of income effects in shaping supply-driven flows using a simple labor market search model with endogenous labor force participation, frictional labor markets, and sticky wages. All else equal, the decline in job-finding rates that occurs after a contractionary shock lowers the returns to search, implying a counterfactual decrease in N to U flows (and increase in U to N flows). We derive closed-form solutions to show that sufficiently strong income effects can outweigh the influence of lower job-finding rates and allow such a model to be consistent with our estimated responses of supply-driven labor market flows.

As indicated above, our findings sharply contrast with the predictions of sticky-wage NK models, where “demand-determined” labor precludes any quantitatively meaningful role for labor supply forces in shaping the response of employment to a monetary policy shock (as discussed in detail by Christiano (2011), Broer et al. (2020), Auclert et al. (2021), and Wolf (2023)). Insofar as our estimates indicate an important role for income effects in explaining the response of labor market flows (and thus labor market stocks) to a monetary policy shock, our paper highlights a potentially important shortcoming of the transmission mechanism in such models.<sup>6</sup> The empirical results in our paper offer a natural benchmark for the quantitative evaluation of NK models with search frictions and active labor supply margins, which can incorporate sticky wages without muting income effects on labor supply.<sup>7</sup>

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<sup>6</sup>See also Golosov et al. (2023), who document the importance of income effects on labor supply from data on US lottery winnings. As pointed out by these authors, the types of labor supply responses that they find in the data are precluded under the class of models generally considered in the sticky-wage NK literature. Thus, we view our study as complementary.

<sup>7</sup>The recent work of Alves and Violante (2023) offers an important first step in this direction.

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 hypothetical impulse response functions when shutting down the response of various labor market flows. In Section 5, we show that cyclical changes in the composition of the labor market play only a modest role in explaining the responses of supply-related labor market flows to monetary policy shocks, but we also document patterns of heterogeneous responses of supply-related labor market flows. In Section 6, we develop a simple labor search model with an active participation margin and sticky wages, where an income effect on labor supply allows the model to be consistent with our empirical estimates. Section 7 concludes and discusses directions for future research. An Appendix provides additional details about the data and robustness of our results.

*Related Literature.* Our paper is related to a large empirical literature studying monetary policy VARs and high-frequency identification, (e.g., Stock and Watson, 2012; Gertler and Karadi, 2015; Ramey, 2016; Bauer and Swanson, 2023b). Impulse responses to monetary policy shocks are useful for understanding the effects of changes in monetary policy (e.g., McKay and Wolf, 2023) and play an important role in evaluating the propagation of demand shocks in the NK model (e.g., Christiano, Eichenbaum and Evans, 2005; Christiano, Eichenbaum and Trabandt, 2016; Auclert, Rognlie and Straub, 2020; Broer, Harbo Hansen, Krusell and Öberg, 2020). We contribute to this literature by offering new evidence for the importance of income effects on labor supply in shaping the employment response to a monetary policy shock.

Our paper is most closely related to a few recent working papers that also study the conditional responses of labor market flows to monetary policy shocks (e.g., White, 2018; Broer, Kramer and Mitman, 2021; Coglianese, Olsson and Patterson, 2022; Faia, Kudlyak, Shabalina and Wiczer, 2022). As discussed by Bauer and Swanson (2023a,b), our instrument for monetary policy shocks incorporates additional interest rate variation around Fed Chair speeches and is orthogonalized with respect to recent macroeconomic and financial market news. This makes our instrument both more relevant and more exogenous than those used by previous authors, giving us more precise and less biased estimates. Additionally, the greater accuracy of our estimates allows us to extend the literature in several ways: by studying the quit and layoff components of flows from employment to non-employment, by considering the role of composition effects in the responses of labor market flows, studying heterogeneity in impulse responses of disaggregated labor market flows, and by analyzing the quantitative importance of the response of supply-driven labor market flows.

Our focus on the separate responses of quits and layoffs is also related to the long empirical literature showing an economically meaningful distinction between

these two reasons for job separation, summarized by Davis (2005). We offer several contributions to this literature: we provide a new decomposition of EN flows into quits and layoffs (in Section 2.2), characterize the decrease in quits and increase in layoffs after a contractionary monetary policy shock (in Section 3.3), and document how past quits and layoffs are predictive of subsequent labor market transitions (in Appendix B.2).

Our paper connects with a literature incorporating a notion of unemployment and labor force participation into the NK model. Models that include search and matching frictions (e.g., Gertler, Sala and Trigari, 2008; Christiano, Eichenbaum and Trabandt, 2016; Graves, 2023) generally assume that labor is supplied inelastically, automatically ruling out any role for labor supply considerations in shaping employment dynamics. While such models are able to match a rise in EU and decline in UE rates after a monetary tightening, they are silent on flows involving a participation decision. A separate class of models introduces some notion of unemployment and labor force participation into an otherwise standard neoclassical labor market. For example, Galí, Smets and Wouters (2012) offers a reformulation of the household block of Smets and Wouters (2007) to incorporate a notion of unemployment. While the strength of income effects on labor supply in their model has virtually no impact on employment—offering an example of “demand-determined” labor in the NK framework—the model nonetheless requires minimal income effects to match VAR evidence on unemployment dynamics. In a similar vein, Christiano, Trabandt and Walentin (2021) study a model where workers choose each period whether to search for work, with only a fraction of searchers finding employment. Their model generates a fall in participation after a contractionary monetary policy shock from a reduction in search effort, contrasting with our finding that search increases along both the intensive and extensive margins in the wake of a monetary contraction.

Although we do estimate a slight (and sluggish) decline in participation after a contractionary monetary policy shock, we show that the decline is driven by an increase in labor force exits and attenuated by a significant increase in labor force entry. This stands in contrast to an influential literature conjecturing that higher unemployment rates discourage labor force entry, thereby suppressing labor force participation, e.g., Perry (1971), Okun (1973), and Clark and Summers (1981). Our results are more consistent with the Hobijn and Şahin (2021) analysis of unconditional cyclical variation in participation, which finds that labor force exits are countercyclical and labor force entry is largely acyclical.

Finally, three other empirical results from our identified shocks also contrast with findings from the macro-labor literature studying unconditional variation in labor market flows. First, we find 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>8</sup>

Second, 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 imply a more limited role for 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.

Third, 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).

## 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 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 labor market aggregates have been widely documented: 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 has very low volatility.

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  $p_{XY}$

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<sup>8</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.

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	8.25	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. The sample is 1978–2019.

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 reports the average labor market transition matrix  $\bar{P}_t$  estimated over our sample, 1978–2019.<sup>9</sup> Table 3 summarizes the cyclical properties of each of the six off-diagonal transition probabilities. The time series of transition probabilities for our sample is plotted in Figure A.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 supply-driven, given that such flows are initiated by workers. The procyclicality of UN flows and countercyclicality of NU flows is evidence of greater job-seeking behavior among the non-employed during downturns. Elsby,

<sup>9</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. For example, see Appendix Figure A.12.

TABLE 2. Average Transition Probabilities Across Labor Market States

From	To		
	E	U	N
E	0.956	0.014	0.030
U	0.255	0.519	0.226
N	0.046	0.025	0.929

*Note:* Transition probabilities are calculated using CPS microdata. The sample is 1978-2019.

TABLE 3. Cyclicalities of Labor Market Flows

	$p_{EU}$	$p_{EN}$	$p_{UE}$	$p_{UN}$	$p_{NE}$	$p_{NU}$
mean	0.014	0.030	0.255	0.226	0.046	0.025
$\text{std}(x)/\text{std}(Y)$	5.19	2.46	5.69	4.14	3.00	5.22
$\text{corr}(x, Y)$	-0.83	0.49	0.78	0.71	0.65	-0.68

*Note:*  $x$  denotes the variable in each column,  $Y$  denotes HP-filtered log real GDP. Standard deviations and correlations are computed for HP-filtered quarterly averages. The sample is 1978-2019.

Hobijn and Şahin (2015) show that this accounts for around 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. Next, we decompose EU and EN flows in a way that allows us to distinguish the separate role of quits and layoffs. Doing so will also shed light on the finding that EU flows are strongly countercyclical while EN flows are modestly procyclical.

**2.2. Decompositions of Separations into Quits and Layoffs.** To understand the extent to which EU and EN transitions are driven by labor supply choices, 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 B.1, along with significant evidence that the distinction between quits and layoffs is economically meaningful.<sup>10</sup> Following our classification of supply-driven flows as those that are initiated by the worker, we interpret quits

<sup>10</sup>Some papers, such as Shimer (2012), express skepticism about the distinction between quits and layoffs, on the basis that in many search models employment relationships terminate when the match

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( $Y$ )	5.19	8.11	7.39	5.44	2.46	5.88	14.42	4.80
corr( $x, Y$ )	-0.83	0.60	-0.85	-0.30	0.49	0.53	-0.44	0.25

*Note:* The process for decomposing EU and EN flows into quits, layoffs and other separations is described in Appendix B.1.  $x$  denotes the variable in each column,  $Y$  denotes HP-filtered log real GDP. Standard deviations and correlations are computed for HP-filtered quarterly averages. The sample is 1978-2019.

as being supply-driven. This decomposition will be important when we separately analyze the response of supply-driven labor market flows in Section 4.

The left panel of Table 4 summarizes the size and cyclical properties of the quit, layoff and other separations components of EU flows.<sup>11</sup> 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 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 cyclicalities of the EU rate is driven by the countercyclicalities of layoffs.

Although many authors have studied the cyclicalities 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 panel of Table 4, we provide a similar—and to our knowledge, novel—decomposition of EN flows into quits, layoffs, and other separations.<sup>12</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 a much larger share of EN flows than layoffs, implying a much more important role for both the magnitude and cyclicalities of quits to non-employment 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

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surplus disappears, and thus it is not obvious that there is a relevant distinction between quits and layoffs.

<sup>11</sup>The time series for our decomposition of EU and EN flows is shown in Figure A.2 in the Appendix.

<sup>12</sup>As we discuss in Appendix B.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.

the literature (e.g., Faberman and Justiniano, 2015), which often equates quits with job-to-job transitions.<sup>13</sup>

In Appendix B we show in various ways that the distinction between quits and layoffs, both to unemployment and to nonparticipation, is economically meaningful. We primarily do this by showing that subsequent labor market transition probabilities are significantly different for individuals that quit their job relative to those who are laid off. For example, individuals that quit to unemployment are around 40 percent more likely to transition to nonparticipation in the next month than those that are laid off to unemployment.

**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. 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 A.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 nonparticipants move to employment is five times smaller than that of the unemployed, the rate at which nonparticipants *who want work* move to employment is just over half that of the unemployed.

Second, we study the number of active search methods of the unemployed 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 A.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

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<sup>13</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 non-trivial fraction of JOLTS quits may reflect quits to nonparticipation rather than job-to-job transitions.

log of the consumer price index, the Gilchrist and Zakrajšek (2012) excess bond premium, and the two-year Treasury yield.<sup>14</sup> This specification is very similar to 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 January 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>15</sup> In order for  $z_t$  to be a valid instrument for  $\varepsilon_t^{mp}$ , it must satisfy an instrument *relevance*

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<sup>14</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 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>15</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.

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).

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>16</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>17</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>18</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.

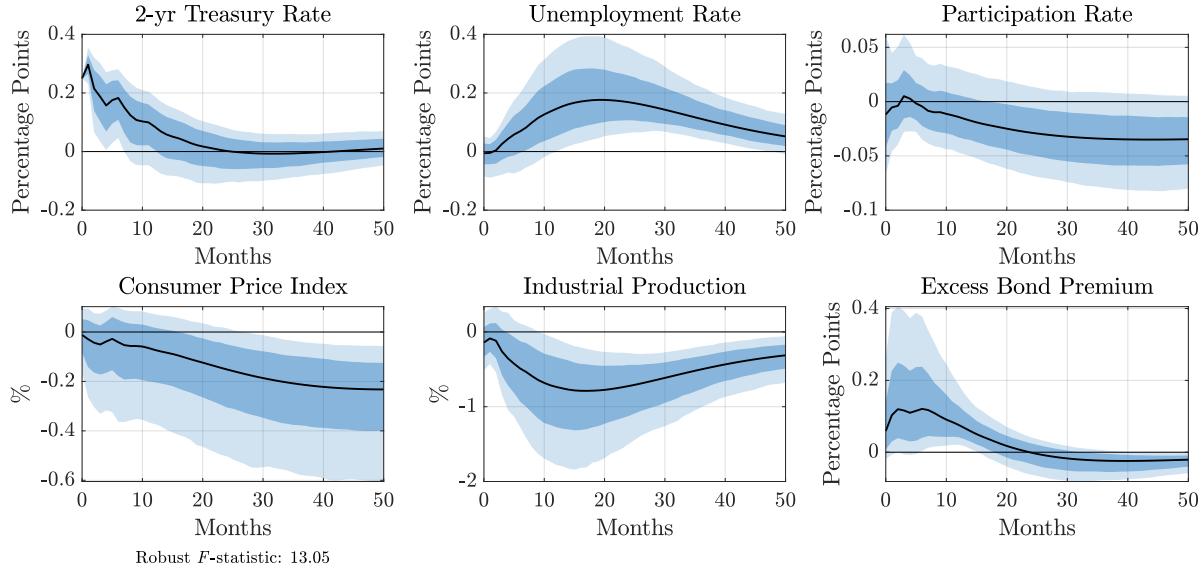
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<sup>16</sup>Swanson and Jayawickrema (2023) use narrow intradaily windows around these announcements and are careful to avoid overlapping with any other macroeconomic data releases.

<sup>17</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>18</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 1. 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. 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.

**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 1. The solid black line in each panel reports the IRF, while dark and light shaded regions report 68% and 90% confidence intervals, computed using a moving block bootstrap 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 Zakrajsek (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 three other variables typically considered in a monetary VAR—unemployment, 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 decrease in the CPI. The peak effect is a little under 0.2 percentage points for the unemployment rate, almost  $-1$  percent for industrial production, 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.

Given our focus on the effect of monetary policy on the labor market, we also estimate the response of the labor force participation rate. Although speeches by monetary policymakers increasingly include references to labor force participation to convey the economy's proximity to "maximum employment" (e.g., Yellen (2014) and Powell (2020)), we are aware of very few papers that quantify the impact of a monetary policy shock on participation. Our estimates suggest that a contractionary monetary policy shock generates a slow-moving decline in labor force participation. Participation begins to fall around six months after impact, reaching a peak effect of around  $-0.04$  percentage points at around 36 months.

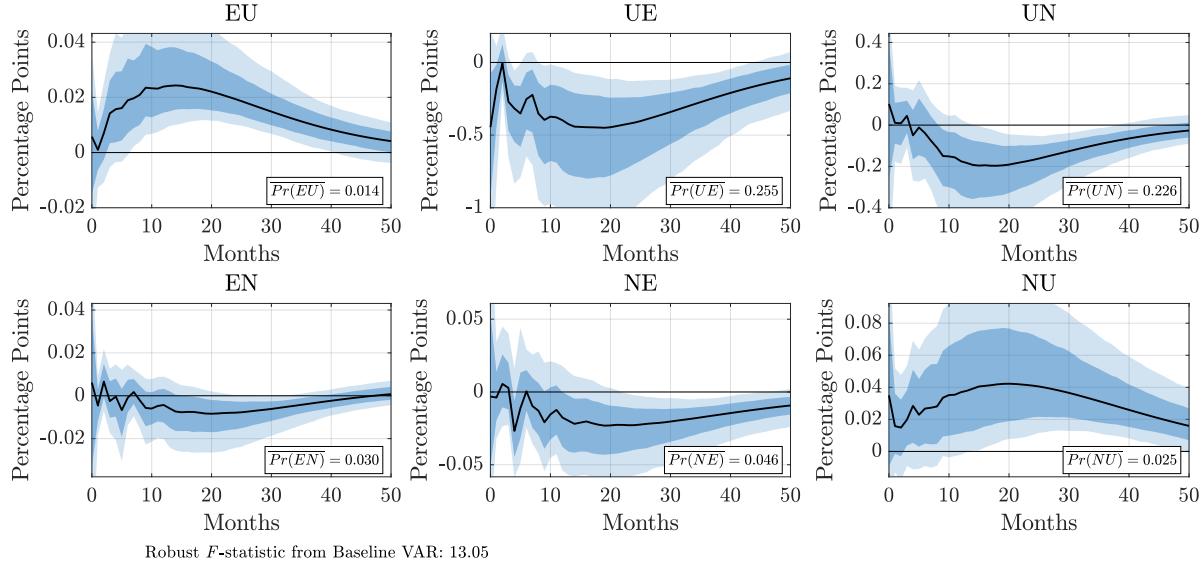
**3.2. Responses of Labor Market Flows to a Monetary Policy Shock.** We next extend our core six-variable monetary policy VAR to include labor market flows. Extending the VAR to include all six labor market flows (EN, EU, NE, NU, UE, and UN) at once would introduce too many parameters into the VAR, resulting 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 2. Each panel in Figure 2 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>19</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 25.5 percent of unemployed individuals move to employment.

In response to a 25bp monetary policy tightening, the labor market flows in Figure 2 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, 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).

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<sup>19</sup>IRFs for the six baseline variables are not reported in Figure 2 in the interest of space, and because they are very similar to those from the baseline VAR in Figure 1.

FIGURE 2. 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 1. 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. See text for details.

The flow from unemployment to employment (UE) in the top middle panel of Figure 2 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 towards zero. Second, our measure 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>20</sup> As a result, our estimates of the IRFs in Figure 2 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 2 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.,

<sup>20</sup>See Figures C.9 and C.10 and the discussion in Appendix C.4 for support of our interpretation of the difference in estimates.

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.<sup>21</sup> Taken on their own, the increase in NU flows and decrease in UN flows tilts the composition of non-employment (unemployment + nonparticipation) towards the unemployed, increasing the fraction of active searchers among the population of non-employed. 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 2 responds similarly to the UE flow, but by a smaller amount. The flow from employment to nonparticipation (EN) in the bottom left panel declines 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 2 suggest that monetary policy operates through both labor demand and labor supply channels. Although the EU, UE, and NE flow responses are all consistent with the conventional wisdom that contractionary monetary policy leads to lower labor demand, the responses of NU and UN flows—and as we will show, EN flows, too—provide novel evidence of a labor supply channel. Intuitively, such evidence can be interpreted as operating through an income effect on labor supply, whereby households facing a weakening economy and worsening employment prospects may increase their labor supply in order to maintain their income and consumption. Note, a role for such an income effect is ruled out in standard sticky-wage NK models, where demand-determined labor precludes such labor supply forces from shaping the employment response to a monetary policy shock.<sup>22</sup>

**3.3. Responses of Quits and Layoffs to a Monetary Policy Shock.** We provide further evidence of the response of supply-driven flows by looking at the differential responses of quits and layoffs to a monetary policy shock. Figure 3 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, as in Section 3.2.

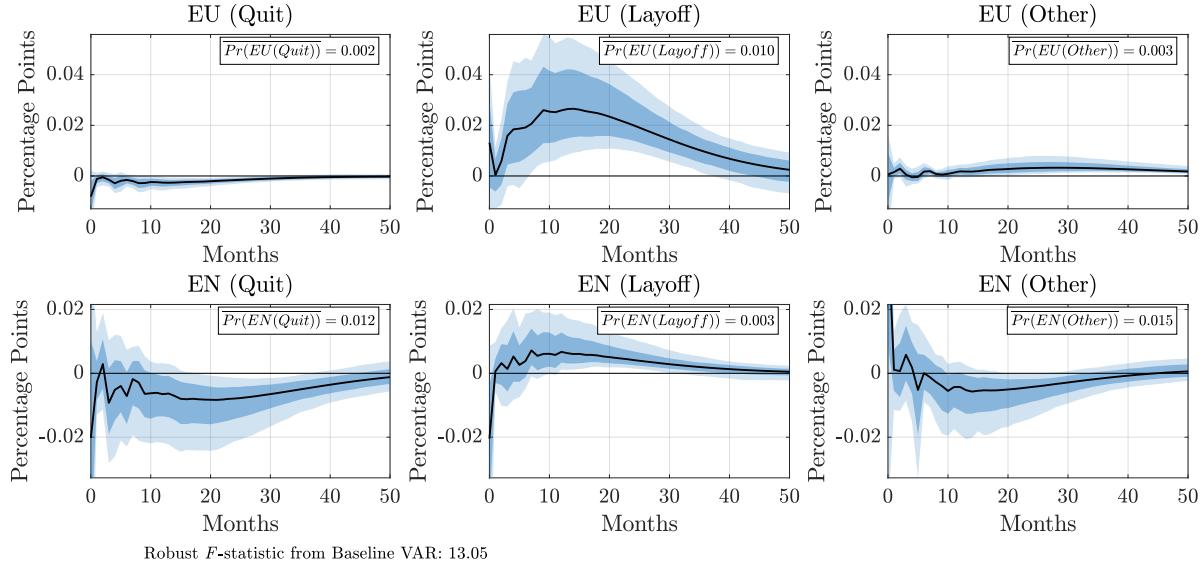
We find that layoffs to both unemployment and nonparticipation rise significantly after a monetary policy tightening. Again, this is consistent with a weakening economy and lower labor demand. In contrast, the quit rate to both unemployment and nonparticipation significantly *decreases* after a tightening, reinforcing the evidence of an increase in labor supply found in the response of UN and NU flows. The portion

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<sup>21</sup>The additional precision attained in adopting the Bauer and Swanson (2023a,b) estimation strategy becomes particularly apparent when studying the impulse responses of UN and NU flows. For example, whereas the estimates applying Romer and Romer (2004) shocks from White (2018) are not significant at 68% confidence levels for most horizons, our impulse responses are estimated with a high degree of precision.

<sup>22</sup>In Section 5 we will show that these results are robust to controlling for cyclical changes in the composition of each employment state. In the Appendix, we also show that these results are robust to a correction for time-aggregation of labor market flows.

FIGURE 3. Decomposition of E-U and E-N Responses



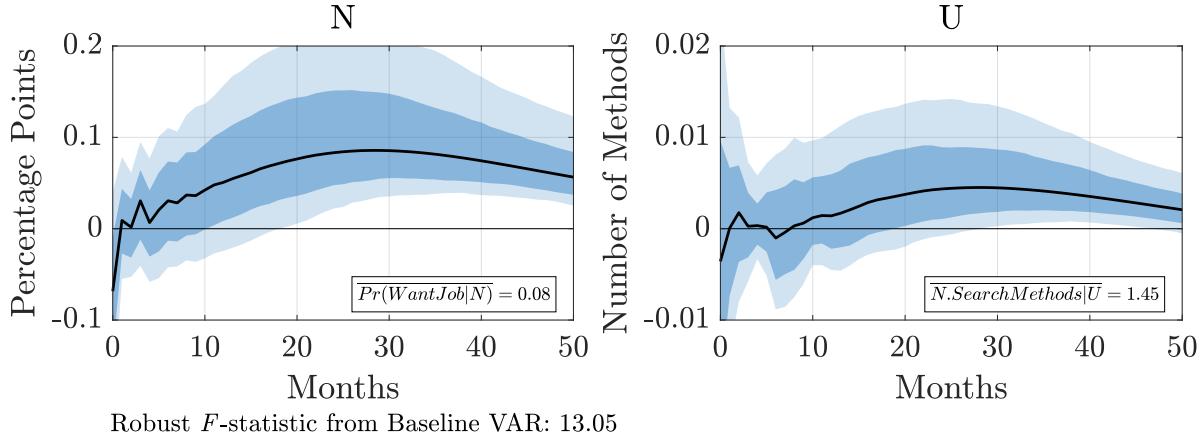
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given labor market flow variable to the baseline VAR from Figure 1. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Inset boxes report average transition rates. Robust F-statistic reported for baseline VAR. See text for details.

of EU flows that cannot be definitively attributed to layoffs or quits increases, while the unattributed EN flow rate declines slightly.<sup>23</sup> As layoffs are a much larger fraction of EU flows than are quits, the overall response of EU flows tracks that of 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.

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 3 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 evidence for an allocative role for wages on separations, as in Jäger et al. (2022) and Davis and Krolkowski (2022).

<sup>23</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 4. Response of Intensive Margins of Labor Supply



*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 1. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Inset boxes report average values. Robust F-statistic reported for baseline VAR. See text for details.

**3.4. Responses of Other Labor Market Variables.** Here, we discuss the response of other labor market variables to monetary policy shocks. We first present evidence on the response of measures reflecting the intensive margins of labor supply. Then, to better understand the flow origins of the decline in labor force participation estimated in Figure 1, we estimate the responses of labor force entry and exit to a contractionary monetary policy shock. Finally, we offer a brief discussion of other estimates appearing in the Appendix.

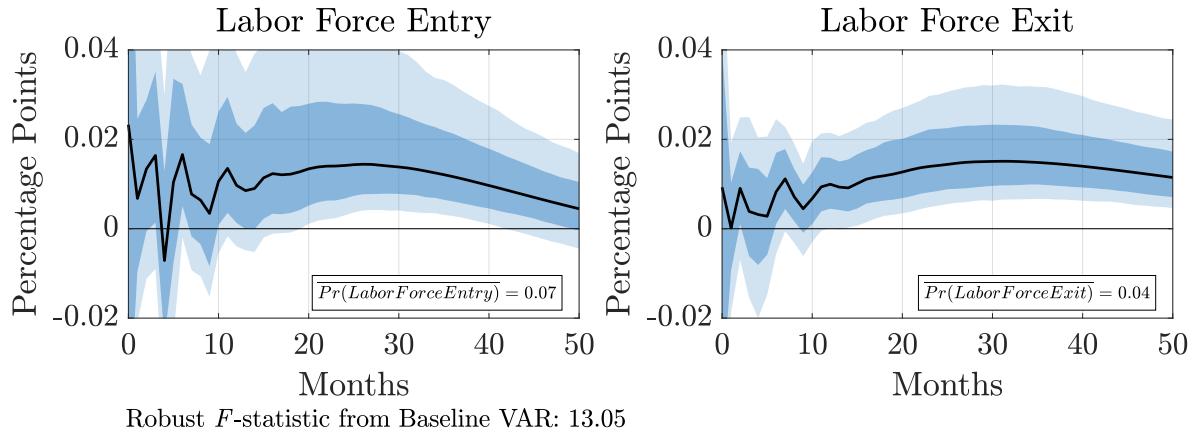
**3.4.1. Responses of Intensive Margins of Labor Supply.** For additional evidence on the response of labor supply to a monetary policy shock, we examine the response of the intensive margins of labor supply for the non-employed.<sup>24</sup> Such responses reflect an increased desire to work and may 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 workers find employment at a substantially higher rate than nonparticipants reporting no desire to work.<sup>25</sup> The left panel of Figure 4 shows the response of the fraction of nonparticipants who report a desire to work. There is a robust and persistent

<sup>24</sup>Cantore et al. (2023) 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.

<sup>25</sup>Nonparticipants that report wanting a job are almost four times more likely to move to employment in the following month than nonparticipants who do not want a job.

FIGURE 5. Response of Labor Force Entry and Exit to a Monetary Policy Shock



*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 1. 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. See text for details.

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 4 shows the response of the number of search methods for 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 probability of finding a job, these findings offer further evidence of an income effect on labor supply, whereby workers place greater value on employment when the economy is weak.

**3.4.2. Labor force entry and exit.** Section 3.1 showed that a contractionary monetary policy shock leads to a sluggish and modest decline in labor force participation. Here, we study the separate contributions of entry and exit into the labor force in generating

the estimated decline in participation from a monetary contraction. Our definition of the labor force entry rate is the rate at which nonparticipants move to either employment or unemployment, while our definition of the exit rate is the rate at which participants move to nonparticipation, on average.

Figure 5 shows the estimated impulse responses to a 25bp contractionary monetary policy shock. Notably, while labor force exit rises, labor force entry rises, too. Thus, the estimated decline in participation from a contractionary monetary policy shock is driven by an increase in labor force exit and attenuated by a simultaneous increase in labor force entry.

To understand the drivers of labor force entry and exit, we express the two flows as follows:

$$\text{Labor force entry rate}_t = NU_t + NE_t \quad (8)$$

$$\text{Labor force exit rate}_t = u_t \cdot UN_t + (1 - u_t) \cdot EN_t \quad (9)$$

From equation (8), we can see that the estimated increase in labor force entry reflects the increase in NU flows plotted in Figure 2, which evidently more than offsets the simultaneous decline in NE flows plotted in the same figure. The forces driving labor force exit summarized in equation (9) are explored in more detail in Appendix C.3, where we show that, to a first-order approximation, the decline in labor force exit from a contractionary monetary policy shock can be understood entirely through the contemporaneous response of the unemployment rate ( $u_t$ ).

Thus, our findings appear inconsistent with the popular narrative originating with Perry (1971), Okun (1973), and Clark and Summers (1981) that an increase in unemployment increases labor force participation by discouraging labor force entry. Instead, our estimates show that a contractionary monetary policy shock leads to increases in both unemployment and labor force entry, the latter driven by increasing flows from nonparticipation to unemployment. Our estimates are consistent with the interpretation given to unconditional cyclical variation in labor force participation by Hobijn and Şahin (2021), that the response of labor force participation to a contractionary monetary policy shock is driven by labor force exit, which itself can be largely understood through the dynamic behavior of unemployment.

**3.4.3. Responses of Additional Labor Market Variables.** In Appendix C.1, 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>26</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.

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<sup>26</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.

We then show that a contractionary monetary policy shock leads to a significant decline in vacancy posting. Through the lens of a matching function, this demonstrates 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 shock in a manner consistent with a decline in labor demand and an increase in labor supply. Here, we evaluate the quantitative importance of the responses of the various labor market flows in shaping the overall responses of the unemployment rate, employment-population ratio, and labor force participation rate to a contractionary monetary policy shock. 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 at its average value, 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 a quantitatively 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—and more pertinently—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.

**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>27</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 the response of unemployment following a monetary policy shock. 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 Greshenny (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 six flows across the three distinct labor market states.

The hypothetical impulse response functions for the unemployment rate are plotted in Figure 6.<sup>28</sup> The solid black lines show the IRF 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 6 show that the counterfactual IRFs holding the 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%.

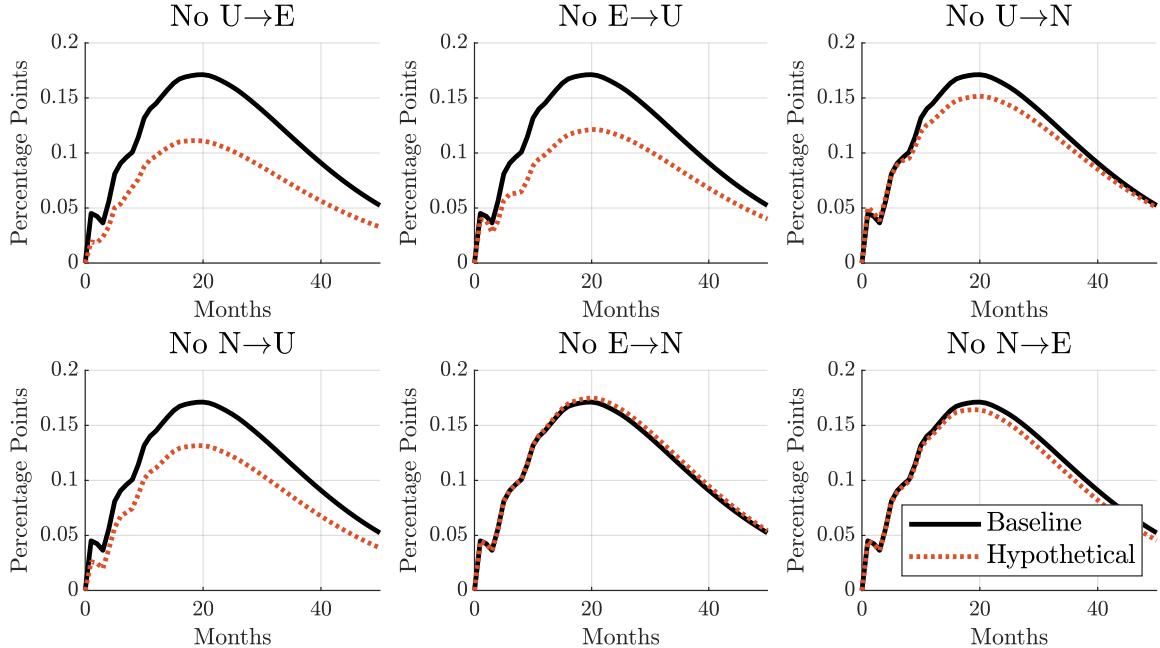
Hence, our estimates imply that EU and UE responses to monetary policy shocks offer roughly equal contributions to the overall change in unemployment following a monetary policy shock. These findings imply that New Keynesian models accounting

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<sup>27</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).

<sup>28</sup>We repeat this exercise for employment and the labor force participation rate in Figures A.4 and A.5 of the Appendix.

FIGURE 6. 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 at its average level.

for the behavior of labor market aggregates in response to monetary policy should offer some mechanism to account for the cyclicity of involuntary separations.

Figure 6 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. These results might be interpreted as evidence that supply-driven flows, particularly quits, are of secondary importance for understanding the overall labor market response to a monetary policy shock. 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 following a contractionary monetary policy shock. To show this, we plot the response of employment in four 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. Third, we shut down the

response of quits to non-employment. Finally, we shut down the response of both quits to non-employment and flows between U and N.<sup>29</sup>

Figure 7 plots the response of employment to a contractionary monetary policy shock in these four scenarios. 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 holding  $U \leftrightarrow N$  flows fixed 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.

To understand the full quantitative importance of labor supply in shaping the response of employment to a contractionary monetary policy shock, we also shut down the response of quits to non-employment. In this scenario, the employment-population ratio falls by roughly 40% more than in the baseline, as we are now turning off the significant decline in quits to nonparticipation identified in Section 3.3. When we shut down the response of both quits to non-employment and flows between U and N to a contractionary monetary policy surprise, we find that the decline in the employment-population ratio roughly doubles.<sup>30</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 work.

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 Appendix Figure A.7. Shutting down the response of supply-driven labor market flows 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>31</sup>

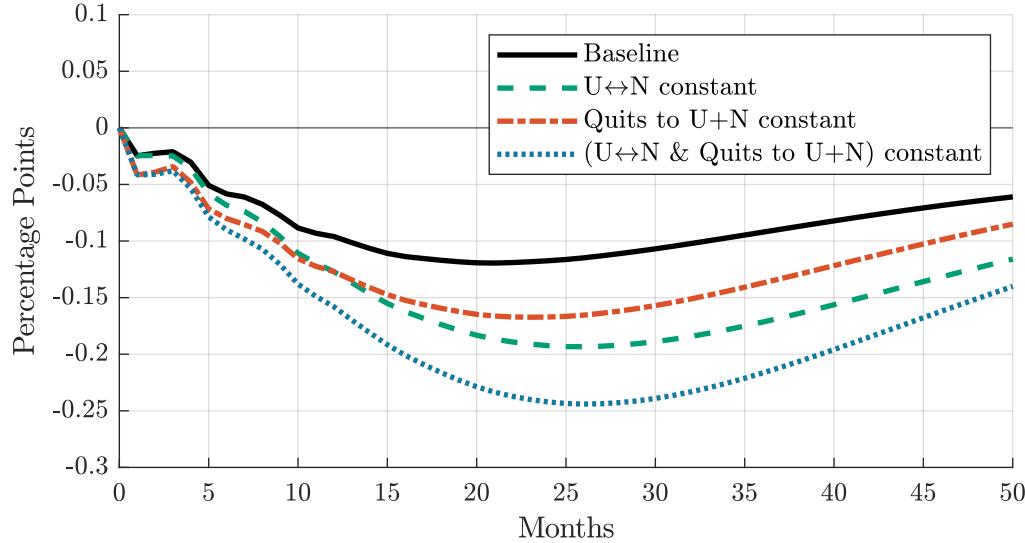
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<sup>29</sup>Figures A.6 and A.7 in the Appendix show the response of the unemployment and participation rates in the same scenarios.

<sup>30</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>31</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.

FIGURE 7. 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 red dot-dashed line shows the response if quits to U or N are held constant. The blue dotted line shows the response if all supply-driven flows are held constant.

## 5. COMPOSITION AND HETEROGENEITY

The estimated impulse response functions for supply-driven labor market flows given in Figures 2 and 3 are consistent with a quantitatively important increase in labor supply to a contractionary monetary policy shock. Here, we establish that these findings cannot be explained by cyclical changes in the composition of each labor market state, indicating that our estimated impulse responses reflect true behavioral responses at the individual level. Then, we explore heterogeneity in the response of supply-driven labor market flows across lower- and higher-educated workers.

**5.1. Composition.** Let  $y_t$  be an aggregate time series of interest, and  $y_{i,t}$  the same time series for a subgroup  $i$  with population share  $\omega_{i,t}$ . Furthermore, denote the time series means of  $y_{i,t}$  and  $\omega_{i,t}$  as  $\bar{y}_i$  and  $\bar{\omega}_i$ . Thus, we can write,

$$y_t = \underbrace{\sum_i y_{i,t} \cdot \bar{\omega}_i}_{\text{variation from } y_{i,t}} + \underbrace{\sum_i \bar{y}_i \cdot (\omega_{i,t} - \bar{\omega}_i)}_{\text{variation from } \omega_{i,t}} + \underbrace{\sum_i (y_{i,t} - \bar{y}_i)(\omega_{i,t} - \bar{\omega}_i)}_{\text{covariance}}. \quad (10)$$

The decomposition given by (10) expresses  $y_t$  as the sum of three components: a component holding composition fixed, given by the first term on the right-hand side;

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Our findings indicate that EU and UE rates play a similar role in the conditional response of labor force participation to monetary policy shocks.

a component allowing composition to vary but holding the variable constant at the group-level, given by the second term; and a final covariance term.

Thus, the time series behavior of a variable  $y_t$  can be thought of as lying between two extremes: one in which its variation is driven entirely by changes in individual behavior, so that the composition of subgroups remains constant (and only the first term on the right-hand side of (10) is non-zero); and another in which the time series variation in  $y_t$  is driven entirely by changes in the composition, with individual behavior remaining constant (so that only the second term on the right-hand side of (10) varies over time).

We estimate IRFs of composition-adjusted labor market flows to identify the contribution of time-series variation in composition to the overall responses of labor market flows to a contractionary monetary shock. Our definition of subgroups follows Elsby, Hobijn and Şahin (2015): we group individuals according to age (16-24, 25-54, or 55+), gender (male or female), educational attainment (less than high school, high school, some college, or BA+), and reason for unemployment if unemployed (quit, layoff, or other). Thus, we consider 72 subgroups for unemployed workers and 24 subgroups for employed or nonparticipants.<sup>32</sup> We then construct the composition adjusted labor market flow from the first term on the right-hand side of equation (10), as in Elsby, Hobijn and Şahin (2015).

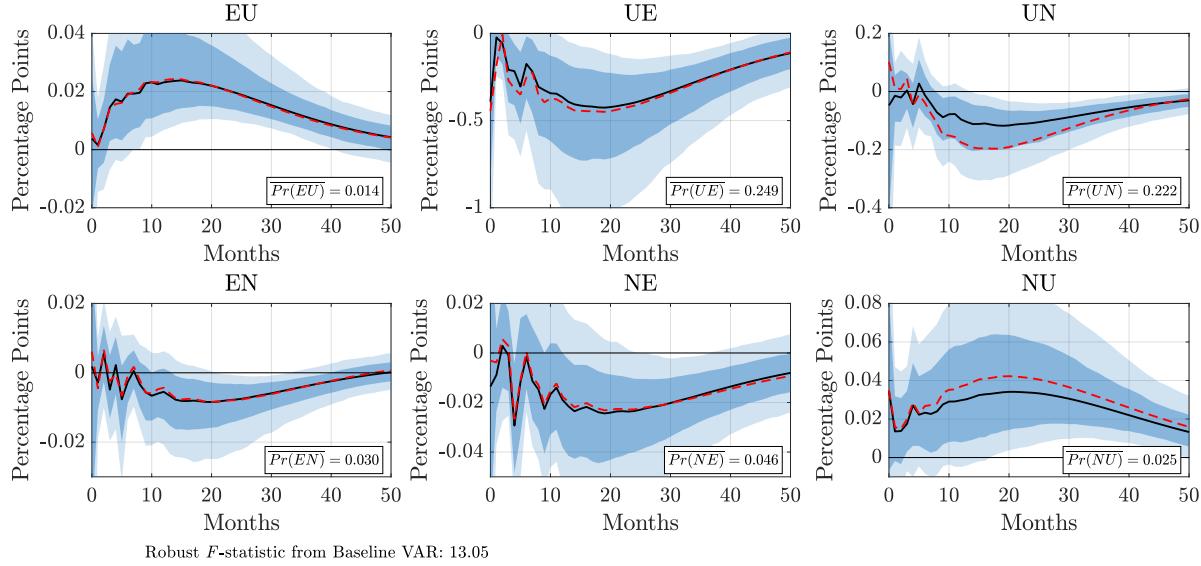
As in Section 3.2, we extend our core six-variable monetary policy VAR; but in this case, we extend the VAR to include composition-adjusted labor market flows. Estimates are given in Figure 8. Compared to the IRFs for the unadjusted flows (shown by the dashed lines), the impulse responses in Figure 8 are broadly unchanged. One important exception is in the response of UN flows, which decreases by roughly one half as much when holding composition fixed, compared to the unadjusted data. This suggests that part of the decline in UN flows to a monetary policy shock reflects a change in the composition of the unemployed towards workers with greater labor force attachment. While our estimate of the role of composition is somewhat smaller, our findings here echo those of Elsby, Hobijn and Şahin (2015), who calculate that roughly 75% of the change in UN flows from the end of an expansion through a recession are due to a change in the composition of unemployment favoring workers more attached to the labor force.<sup>33</sup>

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<sup>32</sup>We differ from Elsby, Hobijn and Şahin (2015) only in that we do not further classify workers according to their labor market status one year prior (e.g., employment, unemployment, or nonparticipation). Such further classification requires studying CPS respondents in rotation groups five through eight; and as shown by Ahn and Hamilton (2022), workers in later rotation groups are a non-representative sample, displaying lower unemployment rates. Thus, we cannot compare the response of flows from such a sample with those in Figure 2. In Appendix C.2, we show that our conclusions regarding the importance of composition are unchanged when considering the full set of compositional characteristics from Elsby, Hobijn and Şahin (2015), but that the IRFs of labor market aggregates appear different, consistent with Ahn and Hamilton's findings.

<sup>33</sup>We conjecture that the greater role for composition found by Elsby, Hobijn and Şahin (2015) may in part reflect their focus on the evolution of UN flows from the *end of an expansion* over the course of a recession; whereas we calculate the impulse response of UN flows starting from steady state (similar to Shimer 2012).

FIGURE 8. Response of Composition-Adjusted Flows to a Monetary Policy Shock



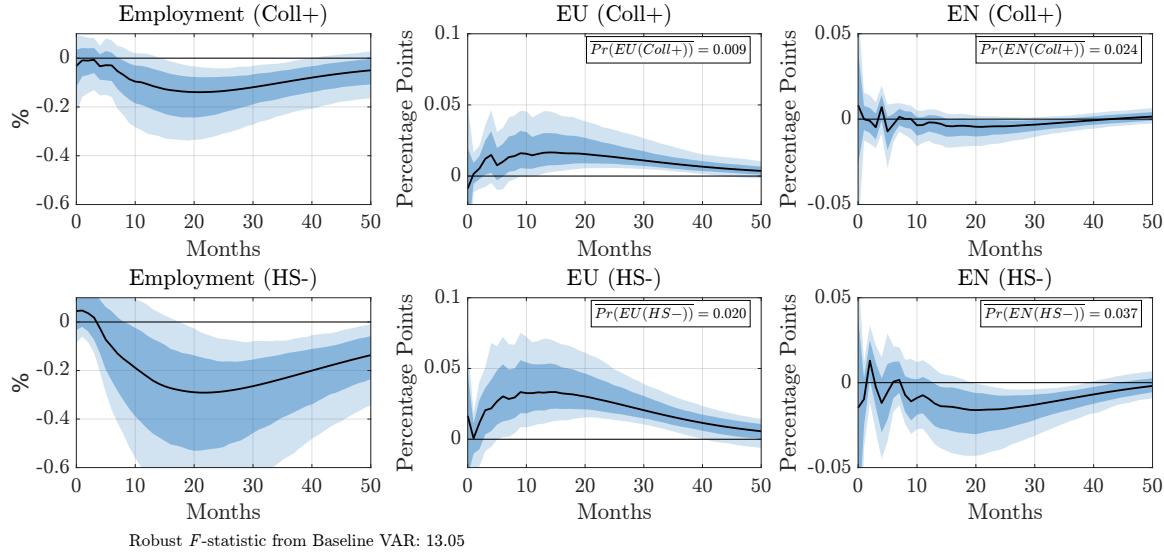
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given labor market flow variable to the baseline VAR from Figure 1. Solid black lines report impulse response functions for composition-adjusted flows, while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals for composition-adjusted flows. Dashed red lines report impulse responses for unadjusted flows, as in Figure 2. Robust F-statistic reported for baseline VAR. See text for details.

Given this evidence, a natural question is whether controlling for composition materially impacts our conclusions of the previous section that labor supply responses play an important role in shaping the response of employment to a contractionary monetary policy shock. In Appendix C.2 we show that it does not. We repeat the accounting exercise presented in Figure 7, where we find that, when controlling for composition, holding supply-driven labor market flows constant still increases the decline in employment after a contractionary monetary policy shock by around 75%. This reflects the fact that, while the response of UN flows is partly muted when holding composition constant, composition has little effect on the other important supply-driven flows: NU flows and quits to non-employment.

Hence, even controlling for composition, our findings are consistent with a robust labor supply increase in response to a contractionary monetary policy shock. Thus, our findings still present a challenge to the standard sticky-wage NK labor transmission mechanism, where there is a limited role for labor supply in shaping the overall response of employment to an unanticipated monetary contraction.

**5.2. Heterogeneity.** While the above section shows that our results on the quantitative importance of supply-driven flows are robust to controlling for composition effects, it does not preclude heterogeneous labor supply responses across different types of workers.

FIGURE 9. 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 1. 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. See text for details.

Here, we study the labor supply response of lower- and higher-educated workers.<sup>34</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 response of supply-driven flows to a monetary policy contraction can be understood through an income effect, we should expect a greater response of such flows from lower-educated workers. We show that this is indeed the case: lower-educated workers exhibit a far greater response of supply-driven flows in the face of a monetary policy contraction, most evidently through a decrease in quits to nonparticipation.

The left column of Figure 9 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

<sup>34</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.

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>35</sup>

In the middle and right panels of Figure 9, 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 little discernible drop for higher-educated workers.<sup>36</sup> The larger increase in employment-to-unemployment flows among less-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.

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 MODEL OF INCOME EFFECTS ON LABOR SUPPLY UNDER STICKY WAGES

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 non-employment. Here, we use a simple partial equilibrium search model to establish that our empirical findings are consistent with a sufficiently strong income effect on labor supply. 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 deterministic steady-state.<sup>37</sup>

<sup>35</sup>Figures A.8 and A.11 in the Appendix show that the difference in responses of employment and labor market flows across high- and low-skill workers shown in Figure 9 is statistically significant.

<sup>36</sup>This is not to say that there is no labor supply response of more educated individuals: Figure A.9 of the Appendix shows a labor supply response among the higher-educated in the form of higher NU flows and lower UN flows in response to a contractionary monetary policy shock.

<sup>37</sup>Our focus on such “indirect effects” of monetary policy follows from findings 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).

The model implies that a contractionary monetary policy shock simultaneously generates both substitution and income effects on job search from non-employment. By the substitution effect, a reduction in the aggregate 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 highlight 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>38</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>39</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  $w$ , job-finding rate  $\lambda$ , and layoff rate  $\delta$  as given. The worker sacrifices some leisure to search, and enjoys no leisure at all when employed. Workers are heterogeneous in the 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  $[b, \bar{b}]$ .

Define  $V_0(b)$  as the value of non-employment in consumption-equivalent units. The worker chooses whether 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 can be expressed as

$$\begin{aligned} rV_0(b) = \max_{s \in \{0,1\}} & \left\{ \frac{b - \psi \cdot \mathbb{I}\{s = 1\}}{\mu} \right. \\ & + (\alpha s + (1 - \alpha))\lambda \left[ \max\{V_1(b), V_0(b)\} - V_0(b) \right] \\ & \left. + \chi \left[ \int_b^{\bar{b}} V_0(b') dF(b') - V_0(b) \right] \right\} \end{aligned} \quad (11)$$

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

<sup>38</sup>We also show that the model generates a reduction in quits in response to a higher marginal utility of consumption.

<sup>39</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).

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 (11).

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

$$rV_1(b) = \max \left\{ rV_0(b), w + \delta[V_0(b) - V_1(b)] + \chi \left[ \int_{\underline{b}}^{\bar{b}} \max\{V_0(b'), V_1(b')\} dF(b') - V_1(b) \right] \right\} \quad (12)$$

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 surplus from employment,  $V_1(b) - V_0(b)$ , is decreasing in  $b$ . We use this result 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 engages in active search. Define  $V_0^{ns}(b)$  as the value of a non-employed worker who does not engage in active search. Then, the threshold  $b^s$  such that  $V_0^s(b^s) = V_0^{ns}(b^s)$  satisfies*

$$\frac{\psi}{\mu} = \alpha\lambda(V_1(b^s) - V_0(b^s)) \quad (13)$$

*Proof.* See Appendix D. □

Equation (13) 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 (13) 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*

$$\frac{b^q}{\mu} = w + \chi \int_{\underline{b}}^{b^q} (V_1(b') - V_0(b')) dF(b') \quad (14)$$

*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>40</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.  $\square$

To see the logic of the proof, see from the Appendix that, if  $\chi = 0$ , equation (13) can be written more simply as

$$\underbrace{\left(\frac{\psi}{\mu}\right)}_{\text{Cost of active search (in consumption units)}} = \alpha \lambda \underbrace{\left(\frac{w - \frac{b^s - \psi}{\mu}}{r + \delta + \lambda}\right)}_{\text{Additional capital gains from active search}} \quad (15)$$

where the term in parentheses on the right side of equation (15) 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. The reduction in  $\lambda$  decreases the rate at which workers find jobs, and thus the relative benefit of search decreases.

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<sup>40</sup>In the Appendix we show that an increase in the layoff rate also decreases the search threshold. We could also consider the response of worker labor supply to changes in wages; however, as we show in Figure C.4, the response of wages to a monetary policy shock is an order of magnitude smaller than that of labor market aggregates such as unemployment.

This represents a pure substitution effect, and so  $b^s$  will thereby decrease, and fewer workers will search. The same is true of an increase in the layoff rate<sup>41</sup>

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

Thus, given a contractionary monetary policy shock that decreases the job-finding rate  $\lambda$  and increases the marginal utility of consumption  $\mu$ , the income effect on labor supply drives non-employed workers to begin searching, whereas the substitution effect does the reverse. Thus, our simple model suggests that our estimates of increasing NU flows and decreasing UN flows after a contractionary monetary policy shock are evidence in favor of a sufficiently strong income effect on labor supply that more than offsets a 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 Christiano (2011), Broer et al. (2020) or Wolf (2023), however, the inclusion of sticky wages into an NK model with a neoclassical labor market-clearing condition precludes any 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 consistent with 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 household labor supply by decreasing the rate at which workers quit jobs to non-employment and stimulating job-seeking behavior among the non-employed. 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.

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<sup>41</sup>Note, the term on the right-hand side of (15),  $\frac{b^s - \psi}{\mu}$ , corresponds to the opportunity cost of leisure, à la Chodorow-Reich and Karabarounis (2016). As explained below, our findings suggest a opportunity cost of leisure that is conditionally procyclical with respect to monetary policy shocks, similar to the unconditional procyclical opportunity cost of leisure documented by Chodorow-Reich and Karabarounis (2016).

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 non-employment is 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 forces 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 simple labor market search model with endogenous labor force participation and sticky wages, we have shown that sufficiently strong income effects can explain the response of supply-driven flows that we find in the data. We believe that incorporating such features into a fully-fledged New Keynesian model is an important topic for future research.

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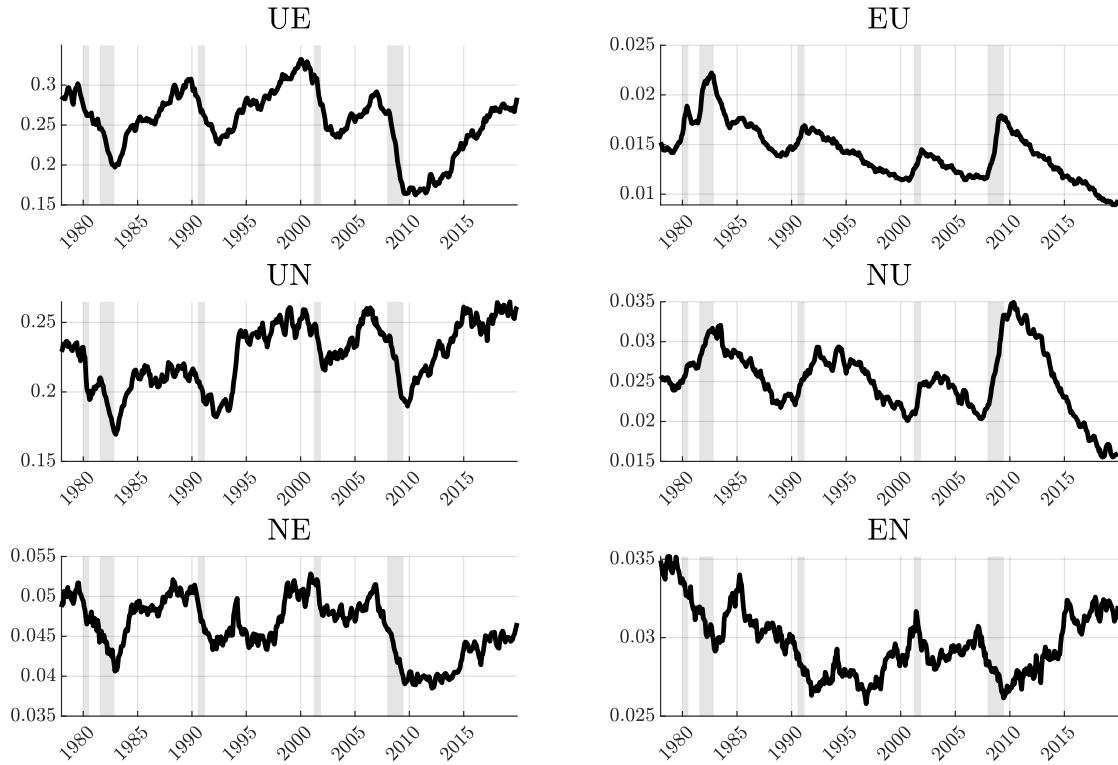
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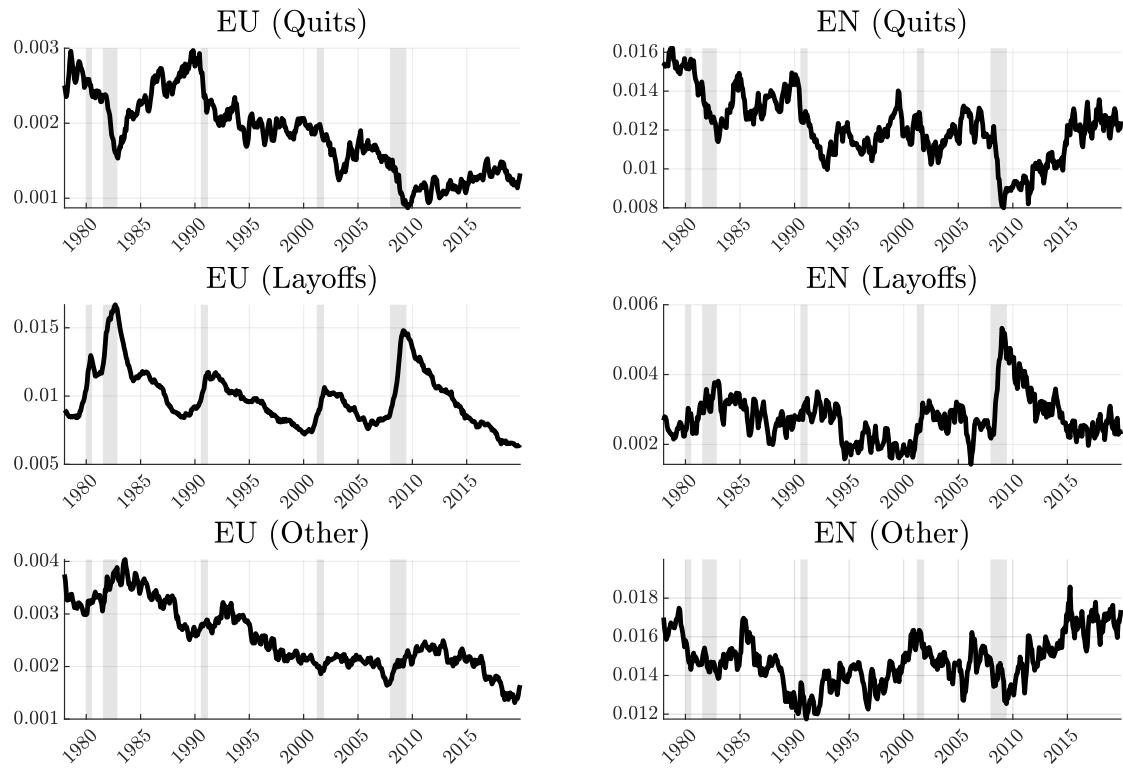
## APPENDIX A. ADDITIONAL FIGURES

FIGURE A.1. Time Series of Labor Market Flows



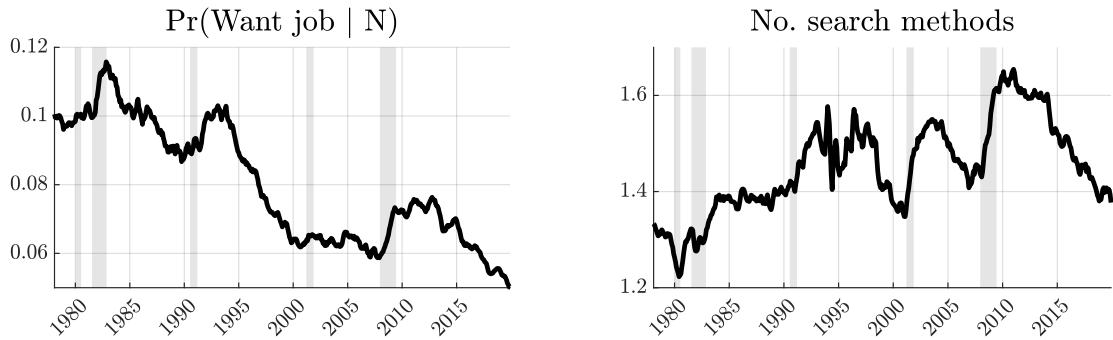
*Note:* Transition rates are calculated using CPS microdata. All series are smoothed using a centered 5-month moving average.

FIGURE A.2. Time Series Decomposition of E-U and E-N Flows



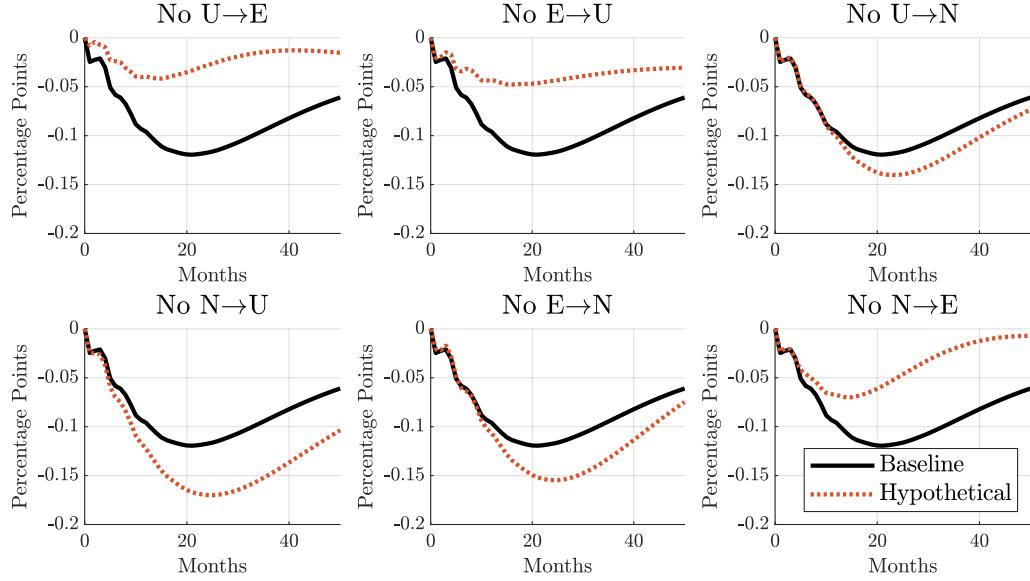
*Note:* Employment-unemployment (EU) and employment-nonparticipation (EN) flows are decomposed into quits, layoffs and other separations as explained in Appendix B.1. All series are smoothed using a centered 5-month moving average.

FIGURE A.3. Intensive Margins of Labor Supply



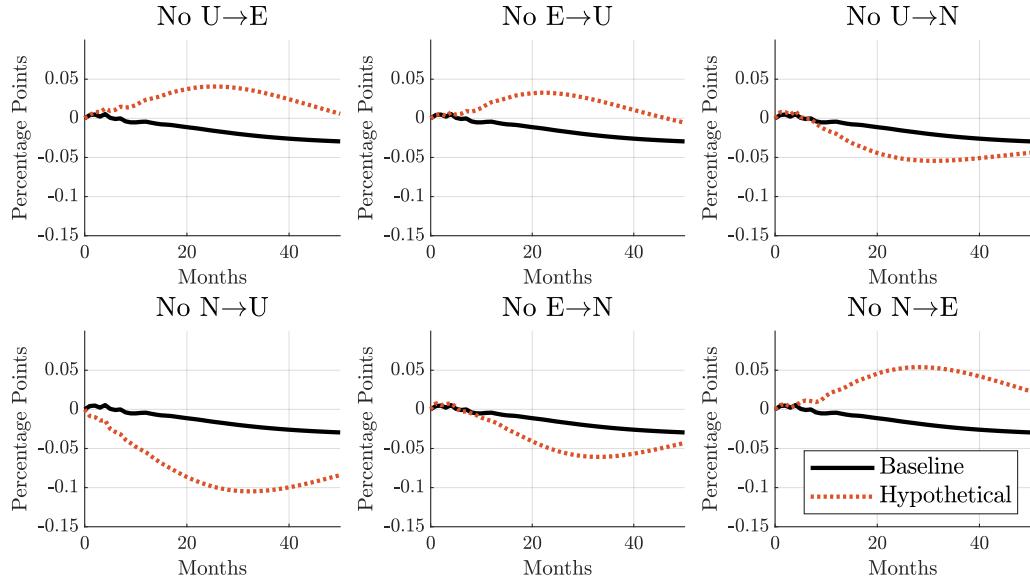
*Note:* We calculate the fraction of nonparticipants that want a job (left-panel) and the number of search methods of the unemployed (right-panel) using the procedure described in Appendix B.5. All series are smoothed using a centered 5-month moving average.

FIGURE A.4. The Ins and Outs of Employment



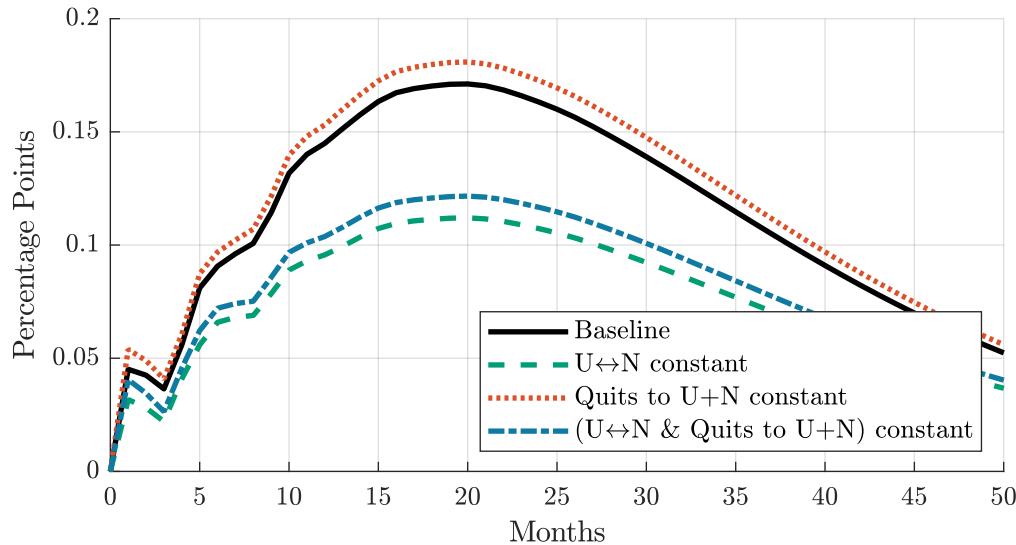
*Note:* The black solid line shows the response of the employment-population ratio to a contractionary monetary policy shock. The red dotted lines show the response if the specified flow rate is held constant at its average level.

FIGURE A.5. The Ins and Outs of Participation



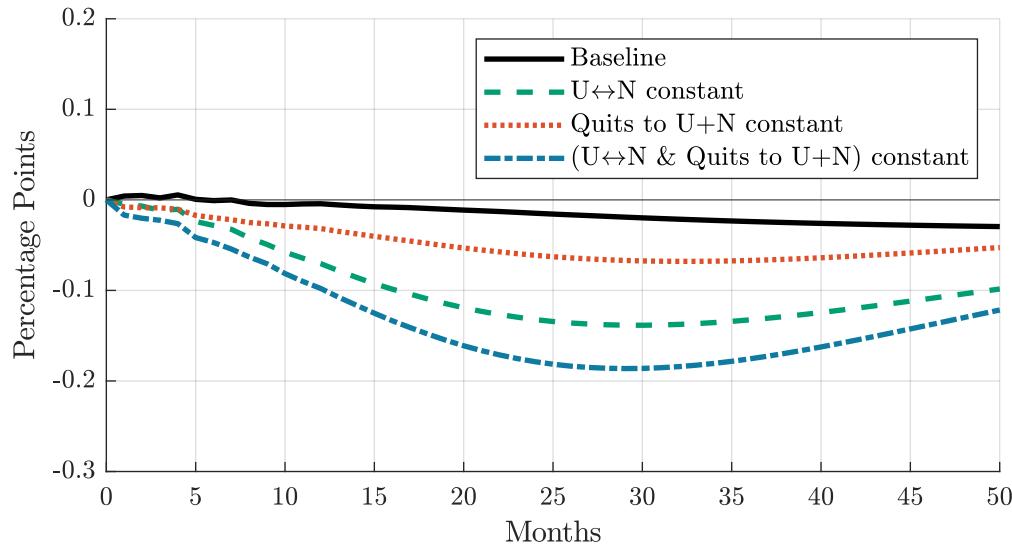
*Note:* The black solid line shows the response of the participation rate to a contractionary monetary policy shock. The red dotted lines show the response if the specified flow rate is held constant at its average level.

FIGURE A.6. Flow-Based Accounting for Unemployment



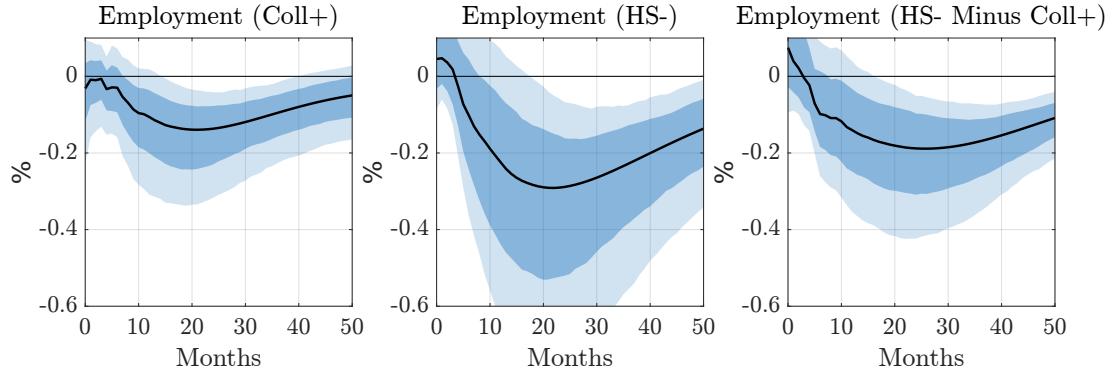
Note: The black solid line shows the overall response of the unemployment rate to a contractionary monetary policy shock. The green dashed line shows the response if both UN and NU rates are held constant. The red dot-dashed line shows the response if quits to U or N are held constant. The blue dotted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

FIGURE A.7. Flow-Based Accounting for Participation



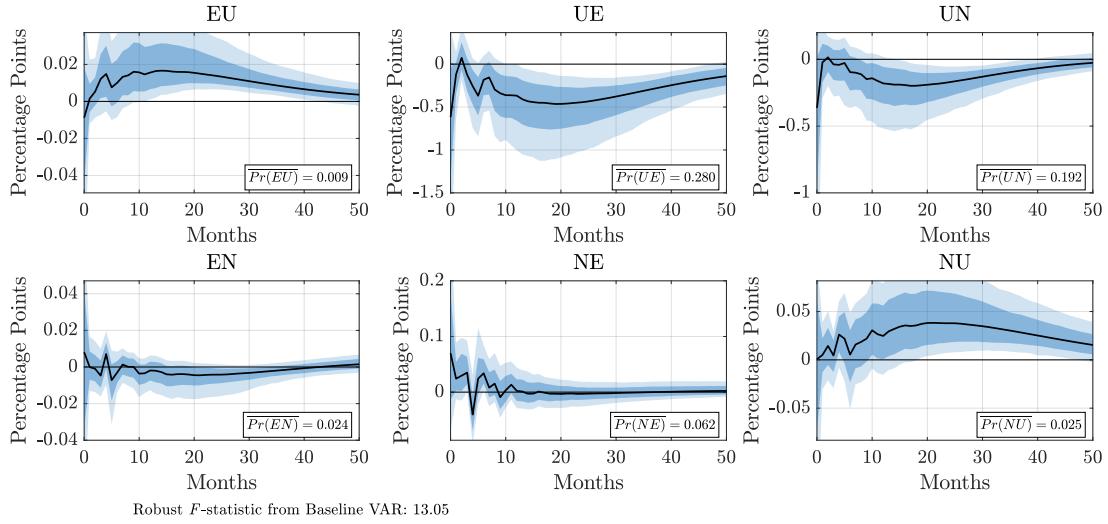
Note: The black solid line shows the overall response of the participation rate to a contractionary monetary policy shock. The green dashed line shows the response if both UN and NU rates are held constant. The red dot-dashed line shows the response if quits to U or N are held constant. The blue dotted line shows the response if all supply-driven flows are held constant.

FIGURE A.8. Response of Employment by Education Level



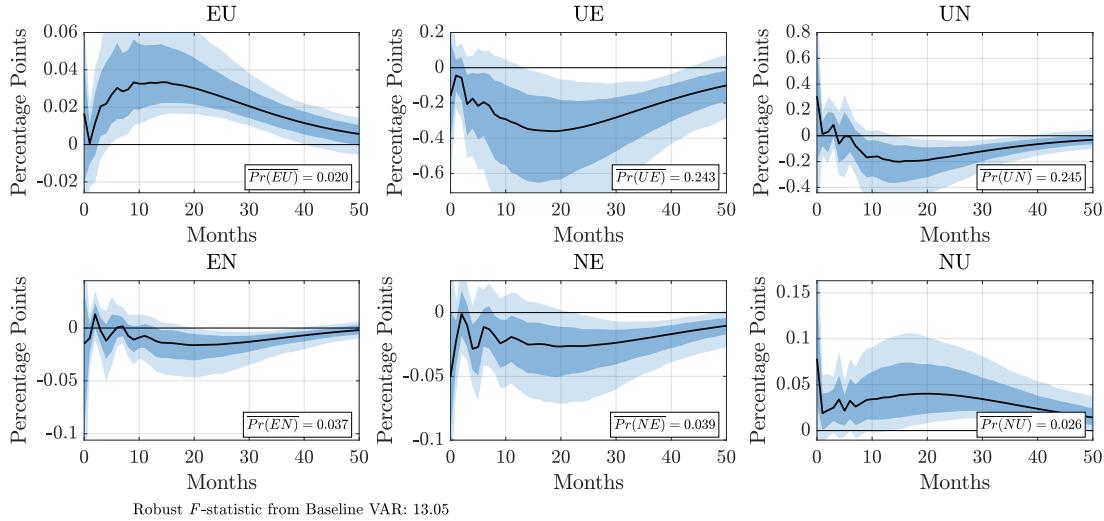
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 1. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals.

FIGURE A.9. Labor Market Flows: Higher-Educated



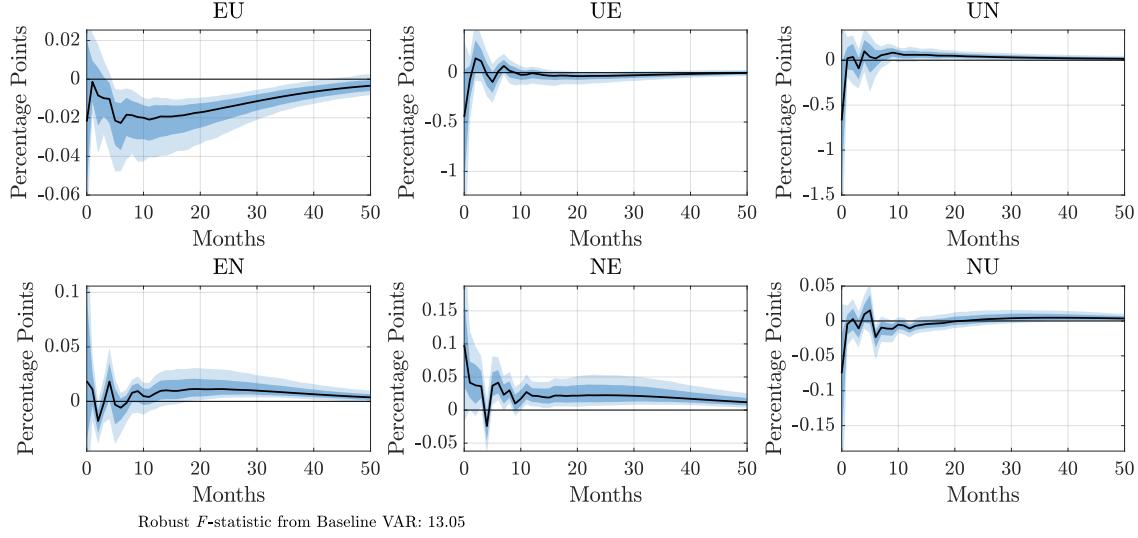
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 1. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Inset boxes report average transition rates. Robust F-statistic reported for baseline VAR from Figure 1.

FIGURE A.10. Labor Market Flows: Lower-Educated



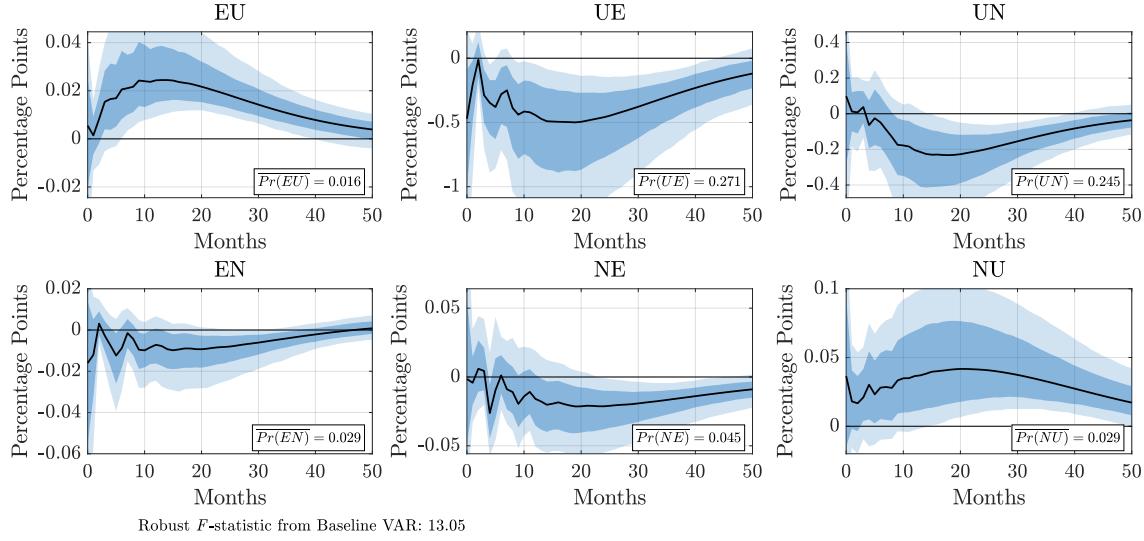
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given variable to the baseline VAR from Figure 1. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Inset boxes report average transition rates. Robust F-statistic reported for baseline VAR.

FIGURE A.11. 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 1. 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.

FIGURE A.12. Response of Time-Aggregation Corrected Labor Market Flows



*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 1. 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 1.

## APPENDIX B. ADDITIONAL CPS MEASUREMENT DETAILS

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. In this Appendix, we discuss how we implement this decomposition, provide evidence on the economic relevance of the quit/layoff distinction, and discuss empirical issues related to the measurement of quits and layoffs across unemployment and nonparticipation.

**B.1. Decomposition of EU and EN Flows: Quits versus Layoffs.** The decomposition of EU flows into quits and layoffs is 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>42</sup> The remaining EU transitions, we label as other separations.<sup>43</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 individuals in the outgoing rotation group that are: (1) not in the labor force and (2) 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>44</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>45</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>46</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

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<sup>42</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>43</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>44</sup>In principle, all individuals that make EN transitions should report having worked in the past 12 months. In practice, a minority do not, as we discuss later.

<sup>45</sup>These are the possible answers from before 1994. After 1994 we define such transitions analogously.

<sup>46</sup>Other EN separations include retirements, disabilities, and the end of temporary seasonal or non-seasonal jobs.

TABLE B.1. Post-EU Transition Rates: Quits vs Layoffs

From	To		
	E	U	N
E–U(Quit)	0.454	0.403	0.143
E–U(Fire)	0.362	0.541	0.097

*Note:* Transition rates are shown for individuals that are in their first month of unemployment following an employment spell, split by reason for unemployment, as defined in Appendix B.1.

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

**B.2. Economic Relevance of the Quit/Layoff Distinction.** Certain papers in the literature have argued against a distinction between quits and layoffs, with a theoretical rationale that follows from Barro (1977): if employment relationships terminate when the match surplus ceases to be positive (e.g., separations are efficient and wages are not allocative for separations), there is no relevant distinction between quits and layoffs (e.g., Shimer, 2005, pg. 35). Under efficient separations, whether a worker's self-reported reason for leaving employment is given as being due to a "quit" or being "fired" is uninformative to the reason why the match dissolved.

We now provide additional evidence—separate from our findings from Section 3.3 that quits to non-employment fall and layoffs rise in response to a contractionary monetary policy shock—that the distinction between quits and layoffs is economically meaningful, by documenting that the subsequent labor market transition probabilities for individuals who quit to either unemployment or nonparticipation are notably different from those of individuals who are laid off.

Table B.1 shows transition probabilities of workers who entered unemployment from employment in the previous month either due to a quit (e.g., E–U(Quit)) or a layoff (e.g., E–U(Fire)). Workers making E–U(Quit) transitions have higher re-employment probabilities and higher probabilities of entering nonparticipation than workers making E–U(Fire) transitions. We can reject the null hypothesis that the two rows of transition probabilities given in Table B.1 are equal using a chi-squared goodness-of-fit test with a p-value that is less than 0.01%.

The same exercise is not possible for EN quits and layoffs, as nonparticipants are only asked their reason for leaving their last job if they are in the outgoing rotation group, and thus we do not see their employment status the following month.

However, we are able to provide evidence that such individuals likely have very different subsequent labor market transition probabilities. Table B.2 shows that those who are laid off to nonparticipation are more than twice as likely to report that they

TABLE B.2. Post-EN Report: Quits vs Layoffs

	Average Probability
Want Job   E-N(Quit)	0.224
Want Job   E-N(Fire)	0.528
NE   Want Job	0.154
NE   Do Not Want Job	0.041

*Note:* The first and second rows show the probability that individuals want a job if they have just made an EN transition, split by the reason for leaving their job, as defined in Appendix B.1. The final two rows show the probabilities of transitioning to employment for all nonparticipants, split by whether or not they report wanting a job.

TABLE B.3. Sequences of Reasons for U among E–U–U Individuals

<i>Sample period</i>	Fire–Fire	Fire–Quit	Quit–Fire	Quit–Quit
pre-Redesign	0.718	0.047	0.053	0.182
post-Redesign	0.759	0.001	0.003	0.238

*Note:* The first row shows the distribution of workers experiencing E–U–U transitions across the four different combinations of reasons for being unemployed, prior to the 1994 CPS redesign. The second row shows the same, but for the period following the redesign.

want a job as those who quit to nonparticipation, and that nonparticipants who want a job are 3-4 times more likely to move to employment in the next month than nonparticipants who report that they do not want work.

**B.3. Measurement Issues in Decomposition of EU Flows.** Shimer (2012) questions the degree to which quits and layoffs can be accurately measured in the CPS, noting that, prior to a 1994 survey redesign, a substantial portion of EU quitters who are newly unemployed in month  $t$  and remain unemployed in month  $t+1$  then report having been laid off. A much smaller portion of those laid off to unemployment in month  $t$  that remain unemployed in month  $t+1$  then report having quit. We reproduce this evidence in Table B.3. In total, around 10% of individuals with E-U-U labor market sequences changed their reason for unemployment before the 1994 redesign of the CPS.

The patterns from Table B.3 have two possible interpretations: First, that quits and layoffs are measured inaccurately in the CPS, as suggested by Shimer (2012). Second, the patterns presented in Table B.3 could be explained by the existence of short-term jobs that are not picked up by the monthly CPS survey. Although we cannot easily distinguish between these two explanations, we next provide evidence that such switching is economically relevant only for a small fraction of individuals.

Table B.4 reports subsequent transition rates for workers having previously made an E–U–U transition during the period prior to the 1994 CPS redesign, with four

TABLE B.4. Transition Rates Across E–U–U Individuals

<i>From</i>	<i>To</i>			Proportion of spells
	E	U	N	
(a) E–U(Fire)–U(Fire)	0.250	0.673	0.077	0.718
(b) E–U(Fire)–U(Quit)	0.354	0.555	0.090	0.047
(c) E–U(Quit)–U(Fire)	0.338	0.556	0.107	0.053
(d) E–U(Quit)–U(Quit)	0.344	0.534	0.122	0.182

*Note:* Transition rates are shown for individuals that are in their second month of unemployment following an employment spell, split by reason for unemployment, as defined in Appendix B.1. The rates are computed for the period prior to the CPS redesign.

separate rows for each possible sequence of reasons for unemployment across the two months: (a) E–U(Fire)–U(Fire), (b) E–U(Fire)–U(Quit), (c) E–U(Quit)–U(Fire), and (d) E–U(Quit)–U(Quit). As shown by comparing rows (a) and (b), we do find that the subsequent transition rates of E–U(Fire)–U(Quit) workers are notably different from E–U(Fire)–U(Fire) workers. However, to the extent that this is driven by measurement error, it is relatively minor: only around 6% of E–U–U workers who initially report being laid off then report having quit in the following month.

A significantly larger fraction (around 25%) of individuals who initially report having quit the job then report having been laid off in the next month. While such switches could represent a concern, we find that these individuals have subsequent labor market transitions that are very similar to those of individuals who continue report having quit their most recent job, seen by comparing rows (c) and (d). Indeed, using a chi-squared goodness-of-fit test, we cannot reject the null hypothesis that the two rows are the same, with a p-value of 0.582. Hence, for such individuals we find that only the reason for unemployment reported in the first month is relevant for predicting future employment transitions.

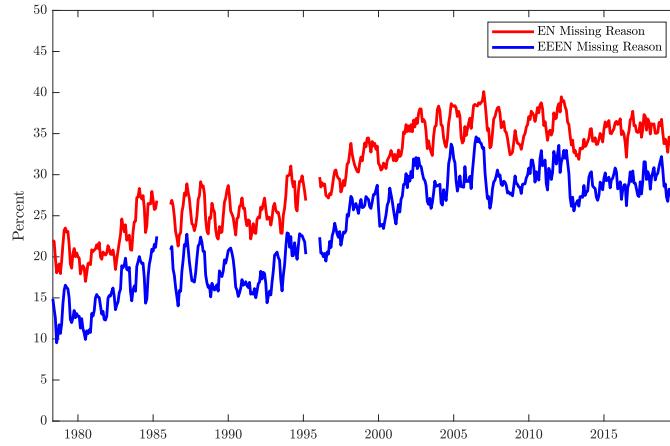
**B.4. Measurement Issues in Decomposition of EN Flows.** Recall, our measurement of quits and layoffs for EN transitions relies on a variable specific to respondents in outgoing rotation groups that codes the reason that the individual left their previous job. For approximately 30 percent of EN transitions that complete on the month of the outgoing rotation group, the value of this variable is missing. The red line in Figure B.1 shows the time-series for the fraction of transitions where the value of the variable is missing. The proportion of EN transitions where the variable is not assigned a value trended up from about 20 percent in the early 1980s to around a third by the early 2000s and has been relatively stable since.

Since 1994, nonparticipants are only asked their reason for leaving their last job if they report that this job occurred during the past 12 months.<sup>47</sup> For individuals that

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<sup>47</sup>For the pre-1994 period it is asked if they report working in the past 5 years.

FIGURE B.1. Fraction of EN Transitions With Missing Reason



*Note:* The red line shows the proportion of individuals making an EN transition for which there is missing data on the reason for leaving the last job. The blue line shows the same calculation for individuals that were employed in each of the first three months before moving to nonparticipation. Series are seasonally adjusted and smoothed using a centered 5-month moving average.

are coded as working in this required time period, there is no missing data on the reason for leaving their job. Thus, data appears to be missing because some fraction of workers recorded making transitions from employment in month  $t$  to nonparticipation in month  $t+1$  are coded in month  $t+1$  as not having worked in the past year. While the conflict of measurement could reflect spurious EN transitions—where employment status was mismeasured in month  $t$ , and the individuals truly never were employed in the past 12 months—we argue that spurious EN transitions could only reflect a small minority of the missing data, and that instead, workers are erroneously recorded as not having worked in the prior year.

First, we find that the share of EN transitions with missing data on reason for leaving a job does not change significantly across subgroups of workers where one might expect meaningful variation in the fraction of workers who are coded as having not worked in the requisite prior time period (e.g., individuals that are not self-employed, that respond to the survey themselves, and that have worked full-time). Moreover, although workers are asked their reason for leaving their previous job within the last five years (instead of one year) prior to 1994, there is no discernible discontinuity in the fraction of workers with an EN transition who are missing a reason for leaving their previous job. If the discrepancy were due to mismeasurement of employment status in month  $t$ , one would expect a discontinuous jump in the fraction of workers with missing data after the change from a five-year window to a one-year window (given that fewer workers from non-employment could report not having worked in the previous five years versus the previous one year).

Then, we compare the incidence of missing data on reason for leaving a job for all EN transitions to the subset of individuals who report three months of employment prior to their transition to nonparticipation (e.g., EEN workers). The latter is plotted in the blue line in Figure B.1. EEN workers are presumably more likely to have truly been employed before their transition to nonparticipation (as otherwise, they would have had three months of incorrectly recorded employment statuses). While the incidence of missing data is slightly smaller for these individuals, still around 25% of observations are missing. We interpret this as further evidence that the missing data are unlikely to be due to misreported EN transitions.

Finally, we develop further evidence that a missing value for this variable does not reflect erroneously reported transitions by examining the subsample of individuals included in the Job Tenure Supplement in the month before they moved to nonparticipation. If we restrict the sample to such individuals who report having worked at their current job for at least one year when answering the Job Tenure Supplement, we still find that, one month later, around 30% of such individuals are classified as having not worked in the past 12 months.

Thus, while it is possible that some individuals are misclassified as employed in the month before they are interviewed as nonparticipants (as in Abowd and Zellner (1985)), we conclude that the dominant source of measurement error stems from workers being incorrectly coded as not having worked in the previous 12 months post 1994 (and previous five years prior to 1994).

**B.5. “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>48</sup>

Our measure of the intensive margin for nonparticipants is the fraction of such individuals who report that they want a job. Before 1994, nonparticipants 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 nonparticipants 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.

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<sup>48</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.

## APPENDIX C. ADDITIONAL RESULTS

### C.1. The Response of Additional Variables.

C.1.1. *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 implies that a contractionary monetary policy surprise should generate a decline in job-to-job transitions.

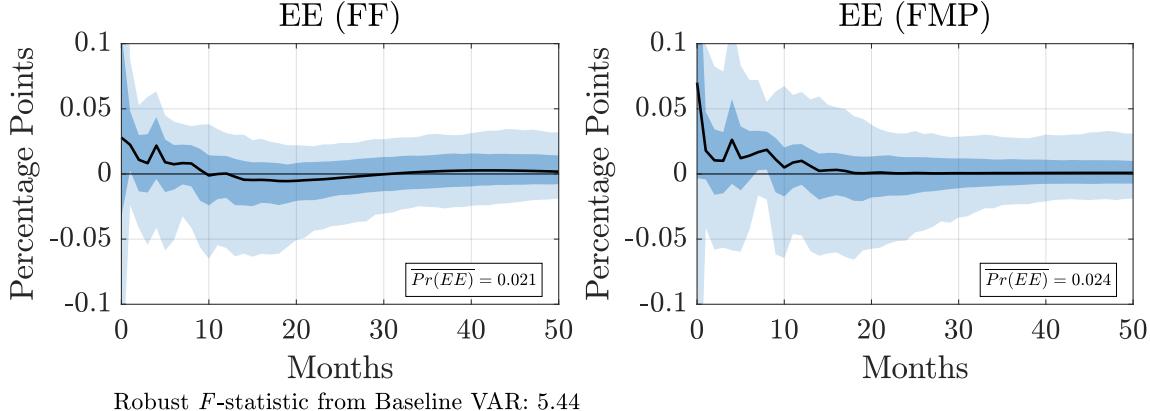
To study the offer-matching theory of inflation, we estimate the IRF for the rate of job-to-job transitions in response to a contractionary monetary policy surprise. We consider two measures of job-to-job transitions: one due to Fallick and Fleischman (2004), and another due to Fujita et al. (2020). 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. In Figure C.2 we show that this is not true for the other labor market flows when estimated over the same sample.

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>49</sup>

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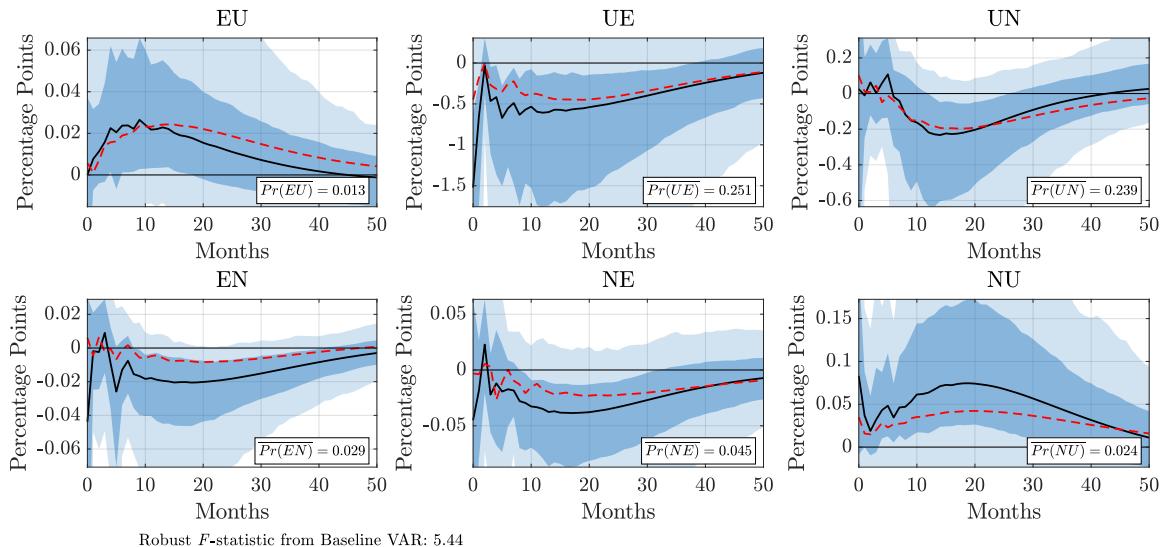
<sup>49</sup>Another feature of the job-to-job transitions data is that it is only available after the re-design of the CPS in 1994. However, we do not believe that this short sample is responsible for the

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



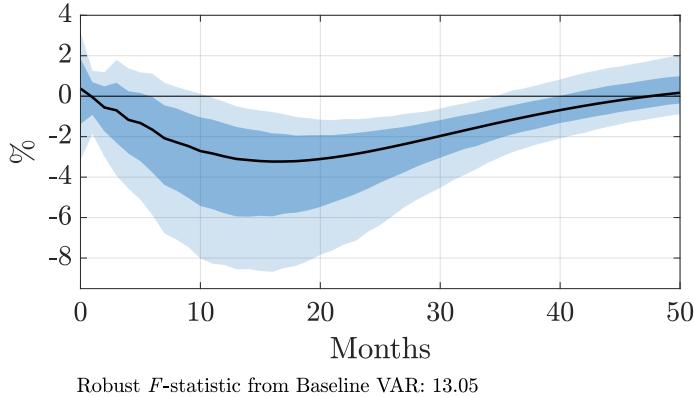
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given labor market flow variable to the baseline VAR from Figure 1. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence 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, estimated since 1995 when the job-to-job change series first becomes available.

FIGURE C.2. Response of Labor Market Flows: 1995-2019 Sample



*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 1. Solid black lines report impulse response functions while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Dashed red lines report impulse responses for the full sample, as in Figure 2. Inset boxes report average transition rates. Robust F-statistic reported for baseline VAR, estimated since 1995 when the job-to-job change series first becomes available.

FIGURE C.3. Response of Vacancies



*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 1. 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. See text for details.

C.1.2. *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 2. All else equal, any increase in unemployment should reduce the rate at which workers from non-employment find jobs.

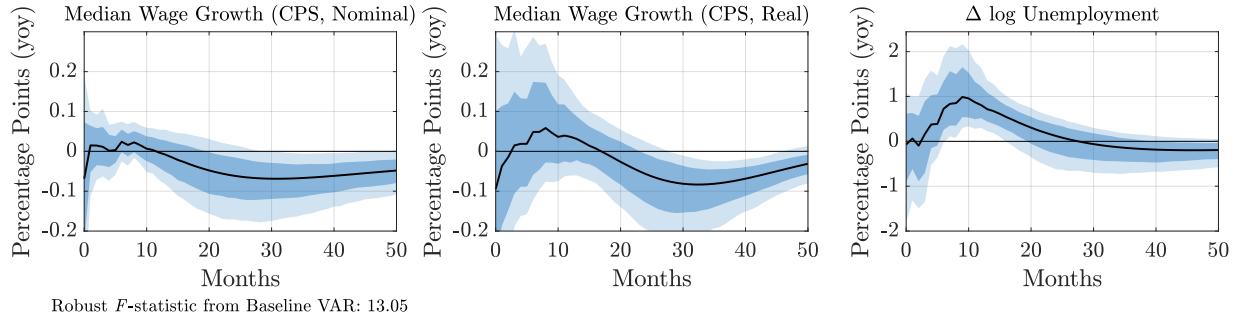
However, a full understanding of the response of UE and NE rates to a monetary policy surprise requires an analysis of vacancy posting by firms. Figure C.3 shows the IRF of vacancies  $v$  in response to a contractionary monetary policy surprise. Vacancies show a gradual decline, reaching a trough at 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.

C.1.3. *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.4 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

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estimated non-response of job-to-job transitions: if we restrict Figure 2 to the same shorter sample the estimated responses are largely unchanged, albeit with larger confidence intervals.

FIGURE C.4. 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 1. 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.

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.

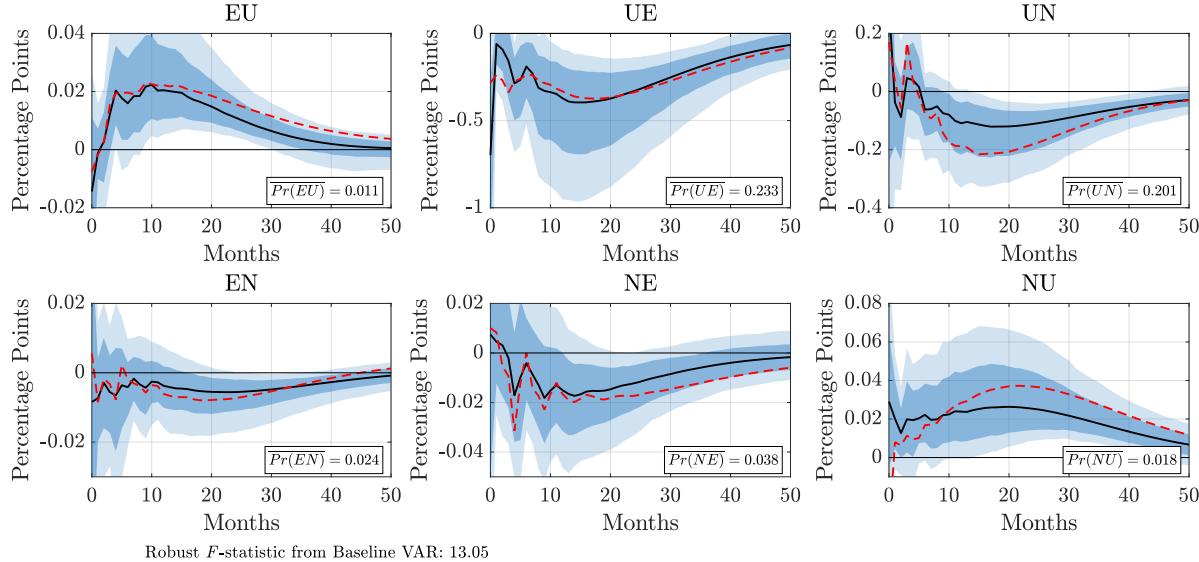
**C.2. Composition.** In this section, we discuss further results when using composition-adjusted labor market flows.

First, we show the response of flows when using flows that are compositionally-adjusted using the full set of controls considered in Elsby et al. (2015). That is, in addition to grouping individuals by combinations of age, gender, educational attainment and (if unemployed) by their reason for unemployment, we now also include their labor market status one year prior.

The reason that we relegate the results using this full set of controls to the Appendix is that it is more difficult to compare our results using this sample to the baseline results. This is because conditioning on employment status one year prior automatically restricts our attention to individuals in the fifth to eighth CPS interviews. These individuals are not representative of the overall CPS sample, as highlighted by Ahn and Hamilton (2022) among other papers.

Figure C.5 shows the response of compositionally-adjusted flows using the full set of controls in Elsby et al. (2015). Qualitatively, the responses look similar to those in Figure 2. However, the quantitative similarity is hard to gauge, given the different samples. One way to see this is in the unconditional transition probabilities. Employed individuals in the Figure C.5 sample are around 25 percent less likely to transition to either unemployment or nonparticipation than those in the full sample (see by comparing inset boxes across Figures 2 and C.5). We also see that nonparticipants in the Figure C.5 sample are significantly less likely to transition to employment or unemployment than those in the full sample.

FIGURE C.5. Response of Composition-Adjusted Flows: Full EHS Controls



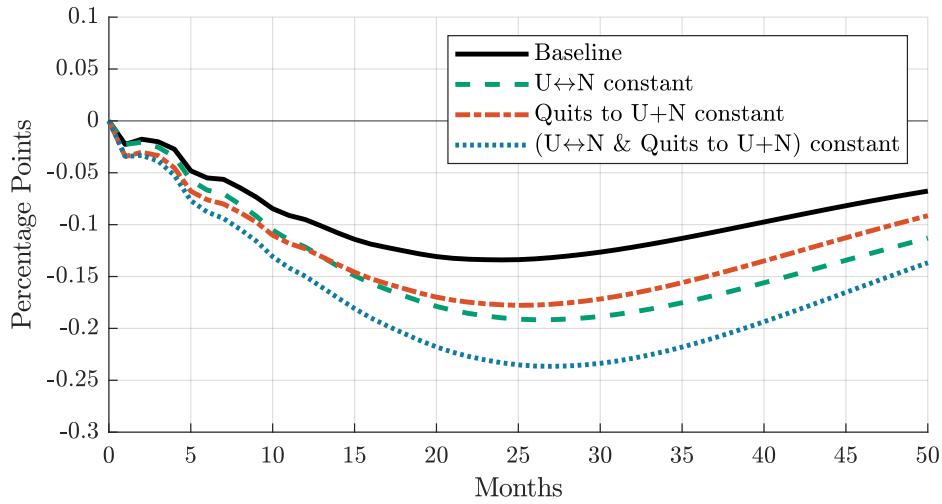
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock, computed by appending the given labor market flow variable to the baseline VAR from Figure 1. Solid black lines report impulse response functions for composition-adjusted flows, while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals for composition-adjusted flows. Dashed red lines report impulse responses for unadjusted flows with the same sample of individuals. Robust F-statistic reported for baseline VAR. See text for details.

To show that our results on the importance of supply-driven labor market flows are robust to compositional adjustment, Figures C.6 and C.7 repeat our flow-based accounting exercise for the response of employment for our baseline compositional adjustment and the full Elsby et al. (2015) compositional adjustment, respectively.

First, looking at Figure C.6, we see that when using our baseline compositional adjustment, the results are similar to those in Figure 7: we find that, when supply-driven flows are held fixed, employment declines by around 75 percent more than when all flows respond.

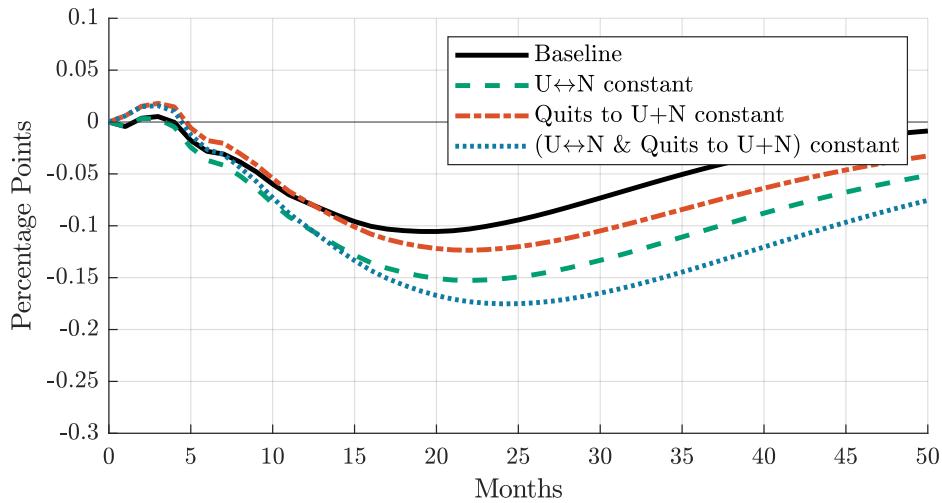
Turning to Figure C.7, the different evolution of employment in the baseline, declining by around 0.1 percentage points rather than 0.15, is further evidence that this is a non-representative subsample. However, when we hold supply-driven flows fixed, we again find that employment declines by around 75 percent more than when all flows respond, showing that our results are robust to even using the full set of EHS controls for composition.

FIGURE C.6. Flow-Based Accounting for Employment: Fixed Composition



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 red dot-dashed line shows the response if quits to U or N are held constant. The blue dotted line shows the response if all supply-driven flows are held constant.

FIGURE C.7. Flow-Based Accounting for Employment: Full EHS Controls



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 red dot-dashed line shows the response if quits to U or N are held constant. The blue dotted line shows the response if all supply-driven flows are held constant.

**C.3. Labor force entry and exit.** To better understand the drivers of the increase in labor force exit from a contractionary monetary policy shock, we loglinearize equation (9) around a deterministic steady state:

$$\widehat{\text{Exit}}_t = \omega \cdot \left( \frac{\widetilde{UN} - \widetilde{EN}}{\widetilde{UN}} \right) \cdot \widehat{u}_t + \omega \cdot \widehat{UN}_t + (1 - \omega) \cdot \widehat{EN}_t \quad (\text{C.1})$$

with

$$\omega = \frac{\tilde{u} \cdot \widetilde{UN}}{\tilde{u} \cdot \widetilde{UN} + (1 - \tilde{u}) \cdot \widetilde{EN}} > 0.$$

where  $\tilde{X}$  denotes the steady-state of variable  $X$  and  $\widehat{X}_t$  denotes log-deviations at time  $t$  of variable  $X$  from its steady-state value.

As shown in Figure 5, labor force exits rise in response to a contractionary monetary policy shock. Thus, given that (a) steady-state UN flows are greater than steady-state EN flows (as reported in the inset boxes of Figure 2) and (b) unemployment is the only variable on the right hand side of equation (C.1) that also increases in response to a contractionary monetary policy shock, we can conclude that, to a first order, the increase in exits to a contractionary monetary policy shock is entirely driven by unemployment and attenuated by declines in UN and EN flows.

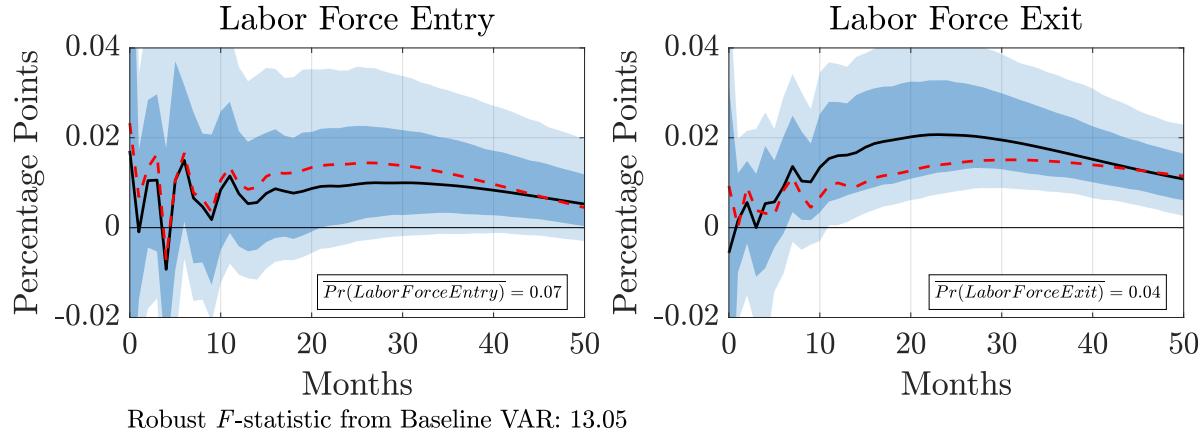
To study the role of cyclical composition in shaping the responses of labor force entry and exit, we repeat the exercise of Section 5, constructing measures of entry and exit that hold the composition of workers within each labor market state fixed. Estimates are given in Figure C.8. We detect a slightly stronger increase in labor force exit once we adjust for composition. This occurs because the composition-adjusted UN rate declines by less, and thus the attenuating effect of this flow on labor force exit (discussed above) is lessened. Hence, both the raw and composition-adjusted flows show that the response of labor force participation to a monetary policy shock is driven by exit, implying an important role for unemployment.

**C.4. Alternative measures of HFI monetary surprises.** In this section, we show the importance of the fact that the monetary policy shocks that we use in the main paper (1) include Fed Chair speeches and (2) are orthogonalized with respect to recent macroeconomic news.

Figure C.9 shows the response of flows if we use high-frequency shocks that are only from FOMC announcement and are not orthogonalized. The results are much attenuated relative to those in Figure 2. This is consistent with the results in Bauer and Swanson (2023b): the fact that unadjusted high frequency shocks are correlated with positive macroeconomic news biases the estimated effects of a monetary tightening towards zero.

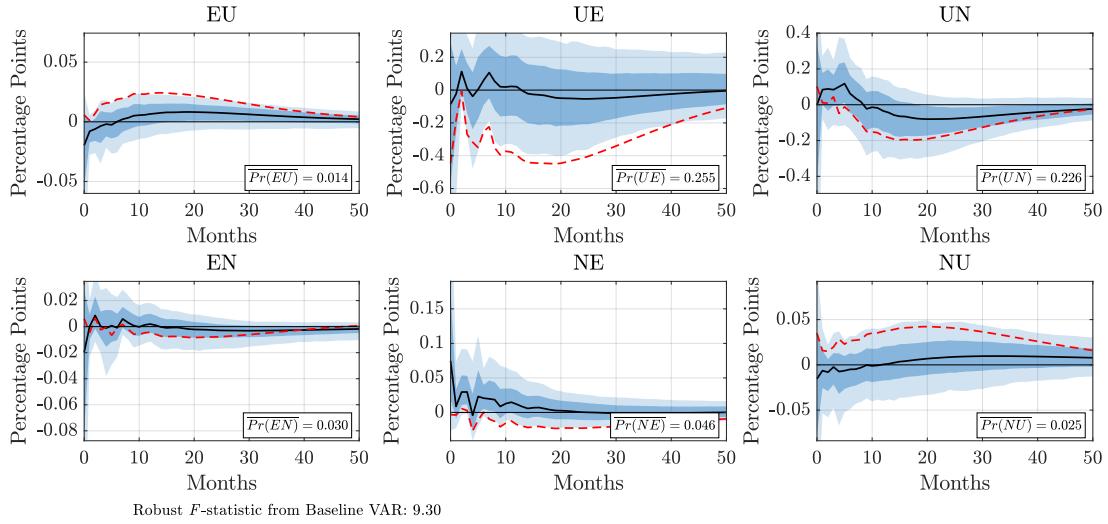
Figure C.10 shows the response of flows if we use this same sample of shocks but orthogonalize with respect to recent macroeconomic news. The attenuation bias is removed from the estimates, but the standard errors increase significantly. There is clear evidence of a weak-instrument problem, with a first-stage F-statistic that is less than 1.

FIGURE C.8. Response of Composition-Adjusted Labor Force Entry and Exit Rates



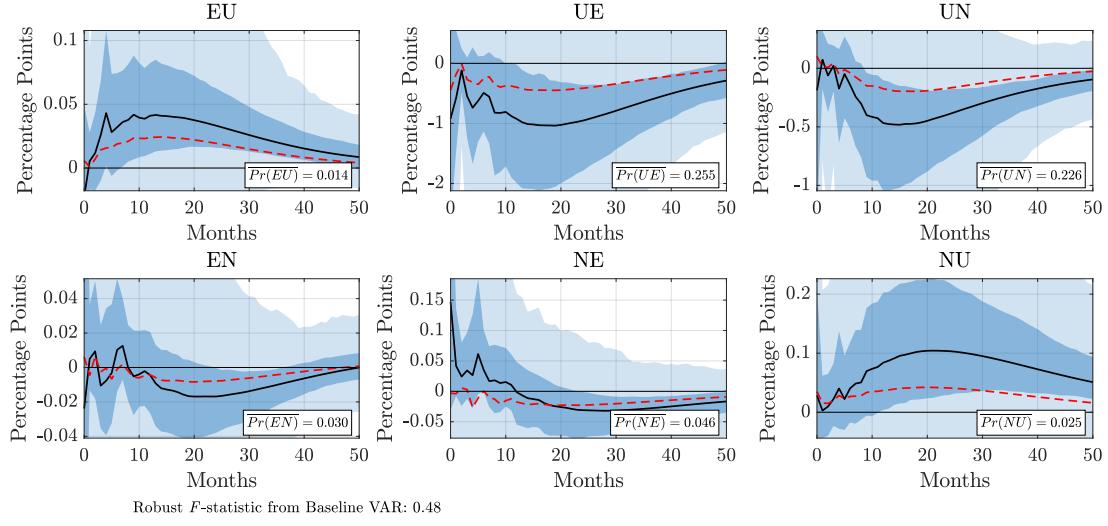
*Note:* Estimated impulse responses to a 25bp monetary policy tightening shock in the baseline VAR. Solid black lines report impulse response functions for composition-adjusted flows, while dark and light shaded regions report bootstrapped 68% and 90% confidence intervals. Dashed red lines report impulse responses for unadjusted flows with the same sample of individuals. See text for details.

FIGURE C.9. 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 1, 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. Red dashed lines report the results from Figure 2. Robust  $F$ -statistic reported for baseline VAR using non-orthogonalized shocks w/o Chair speeches.

FIGURE C.10. 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 1, 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. Red dashed lines report the results from Figure 2. Robust  $F$ -statistic reported for baseline VAR using orthogonalized shocks without Chair speeches.

## APPENDIX D. MODEL APPENDIX

First, we will show that  $V_1(b) - V_0(b)$  is weakly decreasing in  $b$ . We then use this to prove the existence of unique search and quit thresholds. Finally, we specialize to the case with no shocks to the value of leisure, in order to obtain closed-form solutions for these thresholds.

**D.1. Proof that  $V_1(b) - V_0(b)$  is weakly decreasing in  $b$ .** Using equations (11) and (12) for the values of non-employment and employment, write the worker surplus  $rV_1(b) - rV_0(b)$  as

$$\begin{aligned} rV_1(b) - rV_0(b) = \max & \left\{ 0, w - \frac{b - \psi \cdot \mathbb{I}\{s=1\}}{\mu} \right. \\ & - (\alpha s + (1 - \alpha)) \lambda \left[ \max\{V_1(b) - V_0(b), 0\} \right] \\ & + \chi \left[ \int_{\underline{b}}^{\bar{b}} \max\{V_1(b') - V_0(b'), 0\} dF(b') \right] \\ & \left. + (\delta + \chi)[V_0(b) - V_1(b)] \right\} \end{aligned} \quad (\text{D.2})$$

Given that employed workers are always able to quit to non-employment, this surplus is weakly positive. For values of  $b$  where employed workers do not quit, i.e.  $V_1(b) > V_0(b)$ , the above simplifies to

$$V_1(b) - V_0(b) = \frac{w - \frac{b - \mathbb{I}\{s=1\} \cdot \psi}{\mu} + \chi \cdot \int_{\underline{b}}^{\bar{b}} \max\{V_1(b') - V_0(b'), 0\} dF(b')}{r + \delta + [(1 - \alpha) + \alpha \cdot \mathbb{I}\{s=1\}] \cdot \lambda + \chi} \quad (\text{D.3})$$

In this region, a non-employed individual is choosing between searching or not, and will accept a job offer. Thus, we can write the above as

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

where  $V_0^s(b)$  and  $V_0^{ns}(b)$  are the values for a non-employed individual (who will accept a job offer) of searching and not-searching, respectively. The two portions of equation (D.4) are:

$$V_1(b) - V_0^s(b) = \frac{w - \frac{b - \psi}{\mu} + \chi \cdot \int_{\underline{b}}^{\bar{b}} \max\{V_1(b') - V_0(b'), 0\} dF(b')}{r + \delta + \lambda + \chi} \quad (\text{D.5})$$

$$V_1(b) - V_0^{ns}(b) = \frac{w - \frac{b}{\mu} + \chi \cdot \int_{\underline{b}}^{\bar{b}} \max\{V_1(b') - V_0(b'), 0\} dF(b')}{r + \delta + (1 - \alpha) \cdot \lambda + \chi} \quad (\text{D.6})$$

Both (D.5) and (D.6) are continuous and decreasing in  $b$ . Thus, by the continuity of the min function,  $V_1(b) - V_0(b)$  is continuous and decreasing in  $b$ .

**D.2. Proof of unique search and quit thresholds.** Given equation (11), we can write the difference between  $V_0^s(b)$  and  $V_0^{ns}(b)$  as<sup>50</sup>

$$rV_0^s(b) - rV_0^{ns}(b) = \alpha\lambda(V_1(b) - V_0(b)) - \frac{\psi}{\mu} \quad (\text{D.7})$$

This is strictly decreasing in  $b$  and is equal to zero if

$$\frac{\psi}{\mu} = \alpha \cdot \lambda (V_1(b^s) - V_0(b^s)) \quad (\text{D.8})$$

Thus, given appropriate assumptions about the support  $[\underline{b}, \bar{b}]$ , there exists a unique search threshold  $b^s \in (\underline{b}, \bar{b})$  s.t.  $V_0^s(b^s) = V_0^{ns}(b^s)$ . For  $b < b^s$  it is optimal for a non-employed individual to search, while for  $b > b^s$  it is optimal for them not to search.

The existence of a unique quit threshold follows from the proof that  $V_1(b) - V_0(b)$  is continuous and weakly decreasing in  $b$ . This threshold,  $b^q$ , is such that an employed individual quits if  $b > b^q$  and does not if  $b < b^q$ . This is also the threshold at which a non-employed individual is indifferent between accepting or rejecting a job offer. Solving the equation (D.2) for  $V_1(b^q) = V_0(b^q)$ , this threshold is

$$b^q = \mu \left( w + \chi \int_{\underline{b}}^{b^q} (V_1(b') - V_0(b')) dF(b') \right) \quad (\text{D.9})$$

Note, it must be the case that  $b^s < b^q$ ; otherwise, non-employed agents who do not intend to accept a job would make strictly positive gains from not searching. Corollaries 1 and 2 follow.

**D.3. Closed-form solutions when  $\chi = 0$ .** To prove Proposition 1, we set  $\chi = 0$ , substitute equation (D.3) into (D.8), and then simplify to obtain (15). Solving for  $b^s$ , we obtain

$$b^s = \mu w - \frac{(r + \delta + (1 - \alpha)\lambda)\psi}{\alpha\lambda} \quad (\text{D.10})$$

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

$$\frac{\partial b^s}{\partial \mu} = w \quad (\text{D.11})$$

$$\frac{\partial b^s}{\partial \lambda} = \frac{(r + \delta)\psi}{\alpha\lambda^2} \quad (\text{D.12})$$

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 of the job-finding probability  $\lambda$ , operating through a substitution effect; and *increases*

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<sup>50</sup>Note, we are able to focus on the region where individuals accept a job offer, as otherwise there would be no reason to search.

participation through the increase in the marginal utility of consumption  $\mu$ , operating through an income effect.

We could also consider the effect of an increase in the layoff rate. Taking the derivative of  $b^s$  with respect to  $\delta$

$$\frac{\partial b^s}{\partial \delta} = -\frac{\psi}{\alpha \lambda} \quad (\text{D.13})$$

As  $\frac{\partial b^s}{\partial \delta}$  is strictly negative, an increase in the layoff rate will also decrease the search threshold. This is another channel through which a contractionary monetary policy shock may *decrease* participation.

Finally, evaluating equation (14) 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 decreasing in  $\lambda$  through second term on the right side of (14), reflecting the fact that the option value of employment is less important when the job-finding rate is high. Thus, in this case, a contractionary monetary shock will lead to a reduction in quits through both the effects of a higher  $\mu$  and a lower  $\lambda$ .