Layoffs as Missing Quits

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Abstract

We explore a simple proximate cause of the spike in layoffs that characterizes recessions: the contemporaneous decline in quits. The economics is simple, obvious, and almost mechanical: quits and layoffs are substitutes in shrinking firms, so that one additional quit prevents one layoff. Hence, the decline in quits accounts for much of the increase in layoffs in recessions in the following sense: had quits stayed stable in recessions, a large share of the surge in layoffs would not have been implemented. We quantify this quit-layoff link in aggregate time series, industry data, and firm level micro data. We then formalize this channel in an equilibrium search model with multi-worker firms.

The views expressed in this paper are those of the authors and do not necessarily reflect the positions of the Federal Reserve Bank of Kansas City or the Federal Reserve System. Mercan: aymmercan9@gmail.com. Schoefer: schoefer@berkeley.edu.

1 Introduction

A defining feature of recessions is the sharp surge in layoffs. Given the costs of layoffs to firms and workers, a traditional question of macroeconomics and labor economics has been the sources, mechanisms and frictions that shape those layoffs. In this paper, we identify a basic but novel *proximate* source of layoffs: the decline in quits. The intuition is simple: firms' employment evolves as the difference between hires and separations. Separations, in turn, are the sum of layoffs and quits. In firms reducing their employment, a quit is a substitute for a layoff. Hence, fewer quits mean more layoffs. Since quits are high during normal times but plummet during recessions, some layoffs are proximately due to quits in the following sense: they would not have happened had quits stayed stable in an economic downturn. Our paper is the first to explore, quantify and dissect this effect.

Our paper proceeds in three steps. First, we present the mechanism appealing to a simple link between quits and layoffs (and hires) in a firm that adjusts its net employment. The logic can be viewed as a simple establishment-level law of motion for employment stocks in terms of worker flows, using standard definitions of turnover as, for instance, in the Job Openings and Labor Turnover Survey (JOLTS).

Second, we show the potential quantitative relevance of the mechanism by studying the US business cycle fluctuations in worker flows. Namely, we find that the procyclicality of quits and the countercyclicality of layoffs are linked both in terms of timing (i.e., onsets of recessions are times when both quits plummet and layoffs spike), but also in terms of magnitudes. We substantiate this relationship by zooming into *establishment-level* behavior of layoffs and quits by drawing on the empirical "hockey-stick" regularities between turnover rates and net employment growth (Davis et al., 2012, 2013).

Third, we explore the equilibrium consequences of this mechanism for labor market fluctuations. We build a search model of the labor market with heterogeneous multi-worker firms, which adjust net employment through layoffs, quits, and hires.[1] The model generates quits through on-the-job search by workers, which the firms take as given. Firms are exposed to both aggregate and idiosyncratic productivity shocks, leading them to shrink and expand in a way that is broadly consistent with the empirical "hockey stick" graphs for layoffs and hires. In the model, when firms shrink, they seek to adjust net employment to a new level, and they implement the necessary adjustment through layoffs. Layoffs are the difference between the net employment change and quits—so that the model features a one-to-one effect of a quit on a layoff in shrinking firms.

In a recession, more firms seek to shrink. They do so by cutting down hiring—and then rely on separations if a hiring freeze does not suffice. Those firms resort to a combination of natural quits and layoffs—generating a sharp but transitory spike in layoffs at the onset of the recession. For that reason, the model features a crucial role for quits in adjusting the firm size to the desired level.

[1]The model is in the spirit of Cooper et al. (2007); Elsby and Michaels (2013); Fujita and Nakajima (2016), who however do not examine our channel but focus on rationalizing the presence of hires, quits and layoffs at the same establishment—whether expanding or shrinking—and explaining how these variables relate to net employment growth.

As more firms reduce hiring, workers' opportunities to quit to other employers dry up—both in growing and shrinking firms. Hence, as quits plummet during the recession, and workers stay put in their current jobs, these "missing" quits amplify the spike in layoffs. This mechanism is powerful because quits drop substantially in recessions, and the share of firms that shrink through layoffs expands in recessions. Overall, the model hence permits us to investigate the transmission from quits to layoffs in the labor market in equilibrium, and to quantify this link's cyclical effects. We find that a substantial share of layoffs in recessions is due to the decline in quits.

Our paper quantitatively and qualitatively explores a basic mechanism that the existing literature has surprisingly sidestepped so far. The most related papers are studies of multi-worker firms with hiring and separations margins (Cooper et al., 2007; Fujita and Nakajima, 2016; Elsby and Michaels, 2013)—we discuss how those papers are related to ours throughout the model exposition, while noting here that none of the papers have explored the quit-layoff mechanisms explicitly. Davis et al. (2012) come closest to suggesting the mechanism we have in mind, but do not investigate it, and we discuss that reference in more detail in Section 3.3 and Footnote 5. Throughout, we also build on the "hockey stick" insights by Davis et al. (2006, 2012, 2013). Broadly related, our paper recognizes the interplay between various turnover margins—and we view the link between quits and layoffs as related in spirit to the quit-and-replacement-hiring margin in vacancy chain models (Faberman and Nagypal, 2008; Mercan and Schoefer, 2020; Elsby et al., Forthcoming.).

The rest of the paper proceeds as follows. In Section 2, we present the basic mechanisms and show its quantitative empirical power in reduced form counterfactuals. In Section 3, we build a multi-worker firm model embedded in a frictional labor market equilibrium and explore the mechanism theoretically. Section 4 conducts quantitative exercises to dissect its potential relevance. The last section concludes.

2 The mechanism and some evidence

The mechanism in aggregate time series. Figure 1 Panel (a) plots the time series of employment growth along with its components in JOLTS during the Great Recession: hiring and separations as a share of employment, both normalized to 0 for the beginning of the recession. Formally, we trace out the following law of motion for employment:

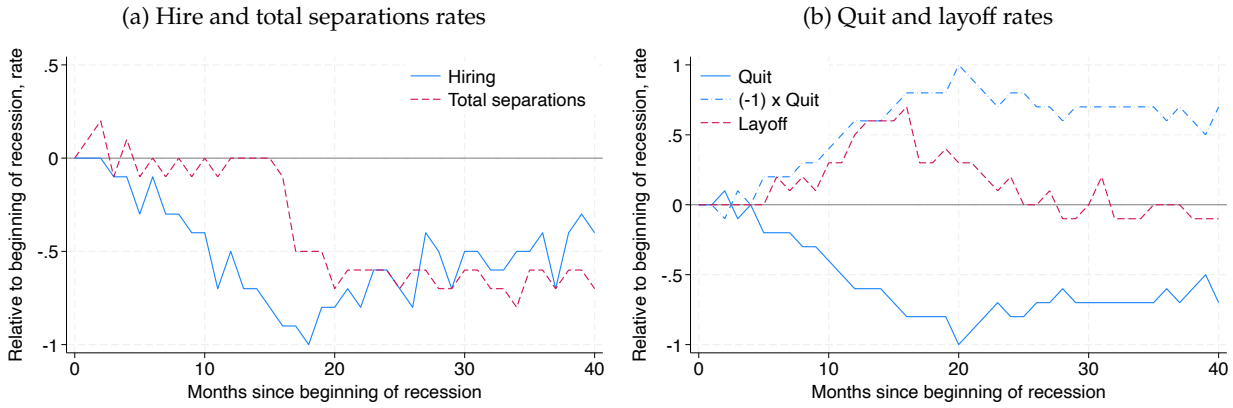
$$N_{t+1} = N_t + H_t - S_t \Leftrightarrow \frac{N_{t+1} - N_t}{N_t} = \frac{H_t}{N_t} - \frac{S_t}{N_t}, \tag{1}$$

where N_t is employment in period t, H_t is hires and S_t is total separations. Separations can be split into quits—initiated by workers, chiefly job-to-job transitions—and layoffs—initiated by firms:[2]

$$\frac{N_{t+1} - N_t}{N_t} = \frac{H_t}{N_t} - \left(\frac{L_t}{N_t} + \frac{Q_t}{N_t} \right). \tag{2}$$

[2]JOLTS offers an "other separations" category, which is small and plays no cyclical role in the aggregate time series.

Figure 1: Labor marker dynamics during the Great Recession



Notes: This figure plots labor market dynamics during the Great Recession using data from the JOLTS. Panel (a) plots the evolution of the hiring and total separations rates relative to their respective values at the beginning of the recession. Panel (b) does the same for the quit and layoff rates. The quit rate is multiplied by -1 to align its procyclical behavior with that of the countercyclical layoff rate.

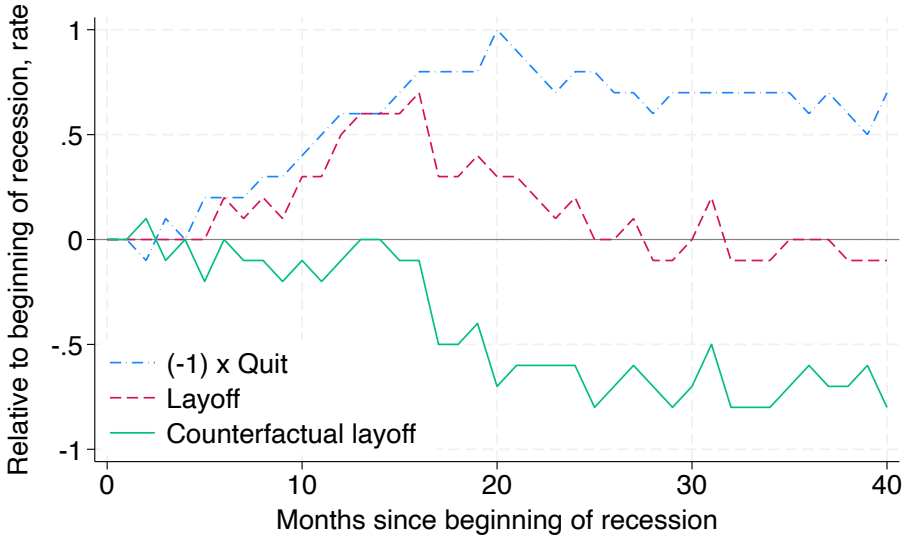
Figure 1 Panel (b) splits up separations into layoffs and quits, again as a share of employment. The time series highlights the procyclicality of quits: when the labor market slackens, employed workers reduce their propensity to voluntarily leave their employer. Potential reasons are that (i) quits into unemployment are less attractive due to the slack labor market, (ii) employed workers are less likely to encounter outside job offers, and (iii) employed workers are less likely to accept job offers. The figure additionally highlights the countercyclicality of layoffs, i.e., layoffs surge at the beginning of a recession, moving in the opposite direction of quits.

Aggregate time series counterfactual. To gauge the potential power of our mechanism, we now ask how the procyclicality of quits amplifies the countercyclicality of layoffs. Both time series comove tightly in opposite directions (i.e., onsets of recessions are times when both quits plummet and layoffs spike) and also their amplitudes are similar in magnitude. As both variables are reported as a share of employment stock, one can equivalently interpret the amplitudes as worker for worker. To this end, we construct a counterfactual layoff time series that subtracts the "missing quits:"

$$\frac{\widetilde{L}_{i,t}}{N_{i,t}} = \max\left\{\frac{L_{i,t}}{N_{i,t}} - \left(\frac{Q_{i,t}}{N_{i,t}} - \frac{\widetilde{Q}_{i,t}}{N_{i,t}}\right), 0\right\}. \tag{3}$$

Here, the assumption is that quits are a perfect substitute for layoffs in firms that are letting go of workers. Zooming again into the Great Recession, Figure 2 depicts this resulting counterfactual time series, together with the actual evolution of quits and layoffs, when we impose the restriction that quits stay constant at their beginning-of-recession level. The counterfactual series reveals that, had quits stayed stable, layoffs would not have spiked at the onset of the Great Recession (and even

Figure 2: Quit and layoff rates during the Great Recession



Notes: This figure plots the quit and layoff rate dynamics during the Great Recession, together with a counterfactual time series for the layoff rate had the quit rate stayed stable at its beginning-of-recession, time 0, level throughout, calculated according to Equation (3).

fallen during the (slow) recovery phase).

Industry and establishment size groups. Appendix Figures A1– A4 replicate this analysis at the establishment size categories and industry levels, respectively, finding similar patterns for the comovement of quits and layoffs during the Great Recession.

The mechanism in establishment-level data. The core mechanism we appeal to plays out at the establishment level, in a micro version of the law of motion in Equation (2):

$$\frac{N_{i,t+1} - N_{i,t}}{N_{i,t}} = \frac{H_{i,t}}{H_{i,t}} - \left(\frac{L_{i,t}}{N_{i,t}} + \frac{Q_{i,t}}{N_{i,t}} \right), \tag{4}$$

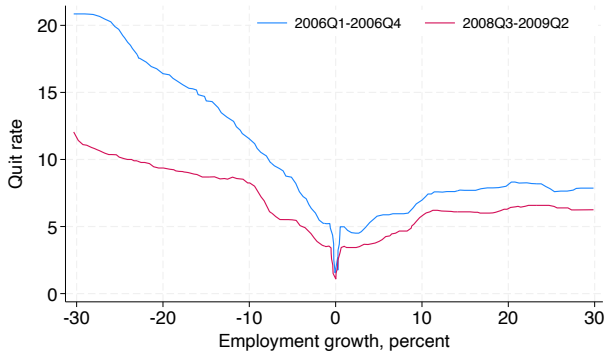
where i indexes an establishment. We now use lower cases for the layoff, hire, and quit rates at the establishment level, and denote by $\Delta n_{i,t}$ the percent change in employment. We derive the layoff amount as a function of hires, quits, and the desired net employment change $\Delta n_{i,t}$:

$$\Delta n_{i,t} = h_{i,t} - l_{i,t} - q_{i,t}. \tag{5}$$

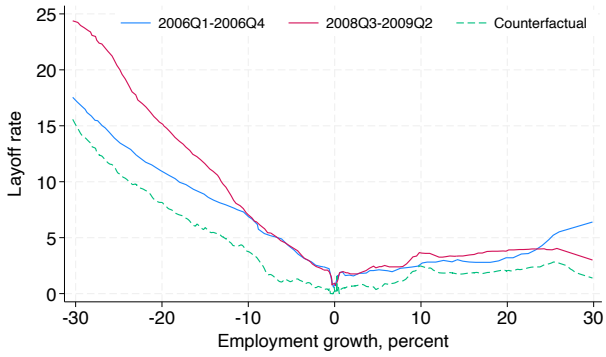
Firm level analysis grouped by growth bin ("hockey sticks"). To make quantitative progress, we now relate the establishment-level dynamics given by Equation (5) to empirical regularities. Figure 3 Panels (a) and (b) plot these "hockey-stick" relationships, building on the seminal work of Davis et al. (2012, 2013), organized by binning establishments by their net employment growth

Figure 3: Establishment-level turnover and employment adjustment during the Great Recession

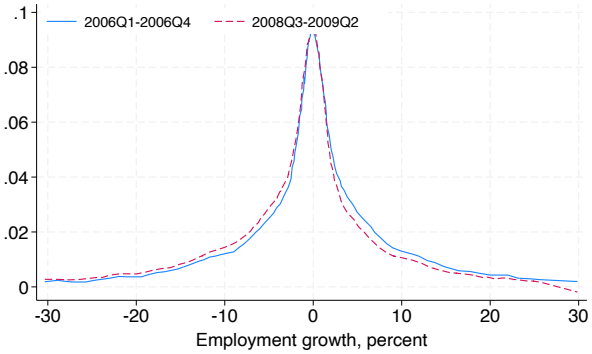
(a) Quit rate by establishment growth



(b) Layoff rate by establishment growth



(c) Employment growth distribution



Notes: Panels (a) and (b) plot the quit rate and layoff rate by establishment growth for two periods: 2006Q1–2006Q4 and 2008Q3–2009Q2.. Panel (b) in addition plots a counterfactual layoff-employment growth relationship had the quit rate stayed at its 2006 level during the Great Recession. Panel (c) plots the employment-weighted establishment growth distribution for the same two periods. The underlying data are taken from Davis et al. (2012).

and plotting the hires, layoffs and quit rates on the y-axis. As is well known, firms that grow do so largely by hiring (and cutting layoffs towards zero), while shrinking firms see little gross hiring and largely shed workers through layoffs (with some increase in quits, the "abandon-ship" effect).

Establishment-level counterfactual layoff rates. We now gauge the role of quits in shaping layoffs using cross-sectional variation as well. Layoff can be viewed as being determined by the three other components of Equation (5):

$$l_{i,t} = h_{i,t} - q_{i,t} - \Delta n_{i,t}. \tag{6}$$

In this law of motion, the substitution between layoffs and quits plays out at a micro granular level, with missing quits only affecting layoffs to the degree that the firm actually implements them. To recognize this constraint, we now construct the counterfactual layoff rate $\tilde{l}_{i,t}$, corresponding to a counterfactual quit rate $\tilde{q}_{i,t} \geq 0$—while assuming that $h_{i,t}$ and $\Delta n_{i,t}$ are unaffected at the

establishment level:

$$\tilde{l}_{i,t} = \max\{0, h_{i,t} - \tilde{q}_{i,t} - \Delta n_{i,t}\} \tag{7}$$

$$= \max\{0, l_{i,t} - (\tilde{q}_{i,t} - q_{i,t})\}. \tag{8}$$

Hence, counterfactual layoff rates inherit the quit gap one for one, up until the constraint of at least zero layoffs. Equivalently, we can express counterfactual layoff rates as actual layoffs minus the minimum of actual layoffs and the quit differential:

$$\tilde{l}_{i,t} = l_{i,t} - \min\{l_{i,t}, q_{i,t} - \tilde{q}_{i,t}\}. \tag{9}$$

Implementation: the Great Recession. We now calculate a counterfactual for the increase in aggregate layoffs drawing on Equation (8) from micro-level establishment dynamics, in the case of the Great Recession.

What underlies our counterfactual is the shift in layoffs in the "hockey stick" graphs in Figure 3 Panel (b), where we plot the counterfactual layoff rate that would prevail if quits in the Great Recession—2008Q3 to 2009Q2—had stayed at their pre-recession baseline level—2006Q1 to 2006Q4. The quit rate shift in this scenario is obtained by comparing the 2006 and 2008 quit gradients, depicted in Panel (a). Panels (a) and (b) makes clear that quits dropped exactly in the establishment growth bins that experienced a surge in layoffs, i.e., the establishments shrinking by 10% or more. However, quits dropped across all bins, implying a large potential for quits to cause the increase in layoffs.

The calculation of the counterfactual layoff rate follows Equation (9). That is, we essentially assume that firms in growth bins are homogeneous in their constellation of turnover bringing about the net employment adjustment.

We summarize our results in Figure 4. This bar chart depicts, for six scenarios, the pre-recession and recession layoff rates, comparing the average layoff rate from 2006Q1 to 2006Q4 to the average 2008Q3 to 2009Q2. The bars denote the average layoff rate we construct for establishments that grow between -30% and +30%, relying on the figures provided in Davis et al. (2012), whose values we extract. Hence, they are not representative of the entire economy and hence cannot be compared to the aggregate time series of layoffs and quits, e.g., from JOLTS.

The first bar captures the pre-recession layoff rate. It is constructed as the weighted average of the layoff rates in the 2006 period with the 2006 employment weights $\omega_{g,t}$, where g denotes an employment growth bin in Figure 3 Panel (c):

$$L_t^{2006,2006} = \sum_g \omega_{g,2006} l_{g,2006} \tag{10}$$

The fourth bar denotes the corresponding 2008 layoff rate,

$$L_t^{2008,2008} = \sum_g \omega_{g,2008} l_{g,2008}. \tag{11}$$

This bar illustrates a sizable increase in the layoff rate from 2006, which we dissect below.

The second and third bars indicate the components of the difference between the 2006 and 2008 layoff rates, respectively denoting the predicted layoff rate from the 2008 (2006) employment growth distribution weighting the 2006 layoff gradient, and the 2006 (2008) distribution:

$$L_t^{2008,2006} = \sum_g \omega_{g,2008} l_{g,2006} \tag{12}$$

$$L_t^{2006,2008} = \sum_g \omega_{g,2006} l_{g,2008}. \tag{13}$$

Finally, the last two bars capture the counterfactual layoff rates that would be prevailing had quits not fallen in the Great Recession—respectively using the 2006 and 2008 employment weights.

$$\widetilde{L}_t^{2006,2008} = \sum_g \omega_{g,2006} \widetilde{l}_{g,2008} \tag{14}$$

$$\widetilde{L}_t^{2008,2008} = \sum_g \omega_{g,2008} \widetilde{l}_{g,2008}. \tag{15}$$

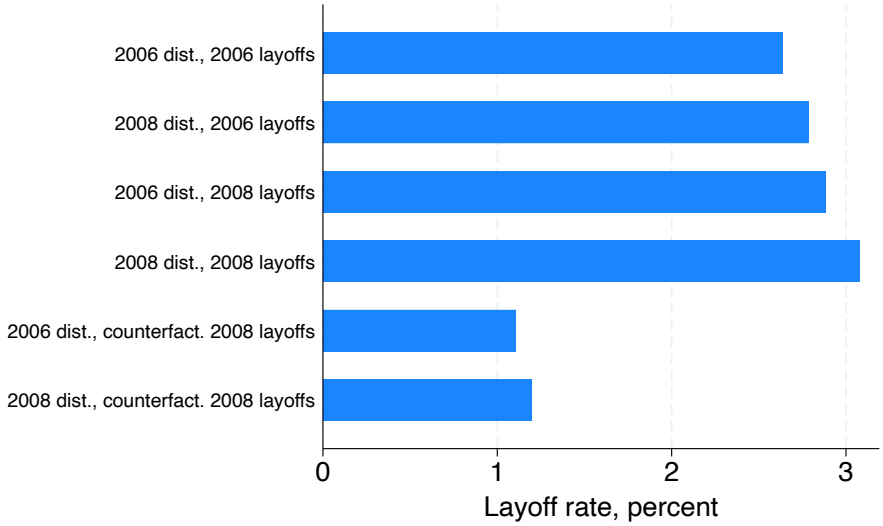
For this counterfactual, layoffs would have plummeted rather than increased during the Great Recession. That is, had quits stayed constant during the Great Recession at their 2006 level, firms' need to implement layoffs would have been largely eliminated. In practice, of course, layoffs occur also in growing firms and/or quits and layoffs may occur in different business lines and are not perfect substitutes. Hence, this exercise underscores the dramatic potential power of the quit-layoff link that we focus on in this paper. We explore how it plays out in an equilibrium model next.

3 An equilibrium model of heterogeneous firms adjusting employment through hires, quits, and layoffs

In this section, we formally and quantitatively explore the equilibrium implications of the quit-layoff mechanism. We present an equilibrium search model with multi-worker firms, which make hiring and layoff decisions subject to idiosyncratic and aggregate shocks in a frictional labor market. Our model closely follows the work of Fujita and Nakajima (2016), who build on the model of Elsby and Michaels (2013), but allow for on-the-job search (OJS), and hence feature quits. For completeness, we present this model in detail.

The framework in Fujita and Nakajima (2016) is the simplest possible existing model with multi-worker firms, quits, layoffs and hires, in which we can explore our mechanism. *However, that paper does not assess the layoff-quit mechanism we are after (nor does any other study in the literature we*

Figure 4: Micro-based counterfactual layoff rates during the Great Recession



Notes: This figure plots aggregate layoff rates calculated as weighted averages of the layoff rates in Figure 3 Panel (b), where the weights are the densities (normalized by the total density) corresponding to each employment growth bin in Panel (c), for different combinations of "hockey-sticks" versus weights for the two time periods considered in Figure 3. See text for the construction of the individual rates. The rates do not align with observed aggregate layoff rates because we restrict the calculations to the establishments with growth within +\-30% of zero.

are aware of).

The model generates quits through on-the-job search by workers, which the firms take as given. Firms are exposed to both aggregate and idiosyncratic productivity shocks, leading them to shrink and expand in a way that is broadly consistent with the empirical "hockey stick" graphs for layoffs and hires. In the model, when firms shrink, they seek to adjust net employment to a new level, and they implement the necessary adjustment through layoffs. Layoffs are the difference between the net employment change and quits—so that the model features a one-to-one effect of a quit on a layoff in shrinking firms.

We then explore how a recession plays out in the model—doing so quantitatively in Section 4. Recessions are initiated by an aggregate negative productivity shock. As a result, more firms seek to shrink. They do so by cutting hiring—and then rely on separations if a hiring freeze does not suffice. Those firms resort to a combination of natural quits and layoffs—generating a sharp but transitory spike in layoffs at the onset of the recession. For that reason, the model features a crucial role for quits in adjusting the firm size to the desired level. As more firms reduce hiring, workers' opportunities to quit to other employers dry up—both in growing and shrinking firms. Hence, as quits plummet during the recession, and workers stay put in their current jobs, these "missing" quits amplify the spike in layoffs. The model hence permits us to investigate the transmission from quits to layoffs in the labor market in equilibrium, and to quantify this link's cyclical effects.

3.1 Environment

Time is discrete. There is a unit mass firms and mass L of workers, both infinitely lived, risk neutral, and discount the future with discount factor $\beta \in (0, 1)$.

Timing. The sequence of events within a model period are as follows. Firms enter the period with idiosyncratic productivity x and employment n, given an aggregate state encoded in s. This aggregate state includes variables/distributions required to forecast future prices.[3] First, the labor market opens: employed workers quit to other jobs, and firms make hiring and layoff decisions, determining their new employment level n'. Then, production takes place and workers are paid wages. The period ends with firms drawing new idiosyncratic productivities $x' \sim G(x'|x)$, and potential aggregate shocks being realized, e.g., to aggregate productivity z.

Search. The labor market is characterized by search frictions. Search is random. Both unemployed and employed workers engage in job search. We normalize the search effort of unemployed workers to one. The employed can search on the job with relative efficiency γ. There is no explicit endogenous search effort margin. Contacts between workers and firms are governed by a matching function of the constant elasticity of substitution (CES) form:

$$M(S, V) = \frac{S \cdot V}{(S^\eta + V^\eta)^{1/\eta}}, \tag{16}$$

where V denotes vacancies and η is the shape parameter. Here, $S = (u + \gamma(1 - u)) \cdot L$ is aggregate search effort and u denotes the unemployment rate. Defining labor market tightness as the vacancy-to-aggregate search effort ratio, $\theta = V/S$, the matching function implies contact probability of $f(\theta) = M(S, V)/S = \theta\,(\theta^\eta + 1)^{-1/\eta}$ for the unemployed worker. Consequently, employed workers receive offers with probability $\gamma f(\theta)$. Each of the firm's vacancies contact a job seeker with probability $q(\theta) = M(S, V)/V = (\theta^\eta + 1)^{-1/\eta}$. We note that the CES specification conveniently ensures contact probabilities to be bounded above by one, $f(\theta), q(\theta) < 1$, as opposed to a perhaps more conventional choice of a Cobb-Douglas matching function.

Production and wages. Firms have access to a decreasing-returns-to-scale production technology given by:

$$y = z x n'^{\alpha}, \tag{17}$$

where n' is the mass of workers that the firm employs in production, z is the level of aggregate productivity common to all firms and x is the firm's idiosyncratic productivity.

For analytical and quantitative tractability, in this baseline version of the model, we simply assume that wages are equal to the value of unemployment benefits, $w = b$.[4] We also assume that

[3] Our experiments that involve aggregate shocks rely on perfect foresight transition dynamics, so we do not make the contents of the aggregate state s explicit.

[4] This simplification follows Fujita and Nakajima (2016), whose model features quits; the model of Elsby and Michaels

workers take any offer they receive, whether out of unemployment or from another job, as the tie breaking rule.

3.2 Firm problem

We cast the firm's problem recursively. The firm's state variables are its beginning-of-period productivity x, beginning-of-period (pre-separation) employment n, and aggregate state s. The firm's value is given by the following Bellman equation:

$$\Pi(x, n, s) = \max_{n' \geq 0} \left\{ z x n'^{\alpha} - w n' - \mathbb{I}_{n' > \widetilde{n}} \kappa v + \beta \mathbb{E}_{x'|x,s'|s} \left[\Pi(x', n', s') \right] \right\}, \tag{18}$$

where n' is the firm's choice of employment in that period. Firms choose employment n' to maximize their revenue net of labor costs subject to search frictions.

Turnover and personnel policies in the model. This model, building on Fujita and Nakajima (2016), who build on the model of Elsby and Michaels (2013), feature rich personnel policies and indeed are the most parsimonious set-up that permits us to explore our mechanism. Most importantly, the model features a distinction between hires, quits, and layoffs. To see this, note that $\widetilde{n} = (1 - \gamma f(\theta)) \cdot n$ is employment after workers quit for other jobs. Hence, $n' - \widetilde{n}$ can be viewed as the firm's active employment adjustment, which can be brought about through layoffs and hires. If firms expand, such that $n' > \widetilde{n}$, they do so by posting vacancies. κ is the flow cost of posting such a vacancy and $v = (n' - \widetilde{n})/q(\theta)$ is the number of vacancies required to hire up to n', accounting for within period worker quits. Implicit in Equation (18) is that downward active adjustment in employment does not incur an adjustment cost, so that for firms with $n' < \widetilde{n}$, layoffs are "free," although we have also explored variants of the model with a firing cost in the form of a constant payment per worker laid off.

Optimal firm policy. We now characterize firms' optimal employment policy. Taking the first order condition (FOC) of Equation (18) yields

$$\alpha z x n'^{\alpha - 1} - w - \mathbb{I}_{n' > \widetilde{n}} \frac{\kappa}{q(\theta)} + \beta \mathbb{E}_{x'|x,s'|s} \left[\Pi_n(x', n', s') \right] = 0. \tag{19}$$

For notational convenience, we define the expected marginal profit function as in Fujita and Nakajima (2016) as:

$$D(x, n, s) = \mathbb{E}_{x'|x,s'|s} \left[\Pi_n(x', n, s') \right]. \tag{20}$$

The fact that hiring is costly due to search frictions, but laying off workers is free, induces a kink in the profit function. This is illustrated clearly in Figure 1 in Elsby and Michaels (2013), whose

(2013) does not feature on-the-job search and hence can accommodate a more general wage bargaining protocol.

model does not feature quits. This kink results in an (s, S) type decision rule for the firm. To this end, we consider two active firm choices, on top of an inaction region.

First, a firm that hires workers above $\widetilde{n}$ adjusts employment until the FOC in Equation (19) holds with the hiring indicator turned on. The solution $n' = R_n^h(x, s)$ then satisfies:

$$\alpha z x R_n^h(x,s)^{\alpha-1} - w - \frac{\kappa}{q(\theta)} + \beta D(x, R_n^h(x,s), s) = 0. \tag{21}$$

Second, a shrinking firm adjusts down its employment until the first order condition in Equation (19) holds with the indicator turned off. The solution $n' = R_n^l(x, s)$ satisfies:

$$\alpha z x R_n^l(x,s)^{\alpha-1} - w + \beta D(x, R_n^l(x,s), s) = 0. \tag{22}$$

In summary, a firm with current state (x, n, s) whose after-quit employment level $\widetilde{n}$ is above the $R_n^l(x, s)$ threshold cuts its employment down to this level and firms below the $R_n^h(x, s)$ threshold hire up to that level. Firms that lie in between these two thresholds stay inactive, but shed workers due to quits. The optimal employment policy can then be expressed more concisely as:

$$n'(x,n,s) = \begin{cases} R_n^h(x,s) & \text{if} \quad \widetilde{n} < R_n^h(x,s) \\ \widetilde{n} = (1-\gamma f(\theta))n & \text{if} \quad \widetilde{n} \in [R_n^h(x,s), R_n^l(x,s)] \\ R_n^l(x,s) & \text{if} \quad \widetilde{n} > R_n^l(x,s). \end{cases} \tag{23}$$

Finally, the envelope condition of Equation (18) that characterizes the marginal profit function is:

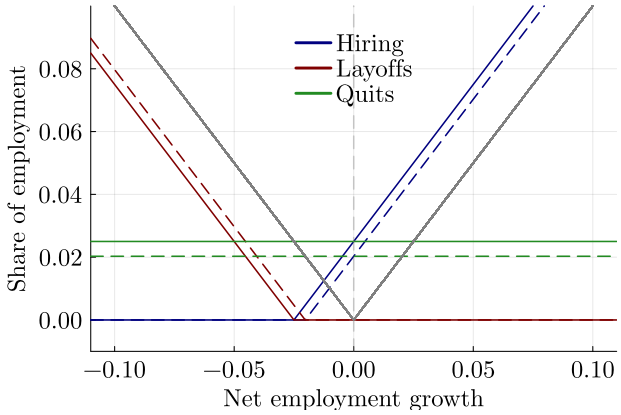
$$\Pi_n(x,n,s) = \begin{cases} (1-\gamma f(\theta))\kappa/q(\theta) & \text{if} \quad \widetilde{n} < R_n^h(x,s) \\ (1-\gamma f(\theta))\left[\alpha z x \widetilde{n}^{\alpha-1} - w + \beta D(x,\widetilde{n},s)\right] & \text{if} \quad \widetilde{n} \in [R_n^h(x,s), R_n^l(x,s)] \\ 0 & \text{if} \quad \widetilde{n} > R_n^l(x,s). \end{cases} \tag{24}$$

We saliently reiterate that these derivations closely follow Fujita and Nakajima (2016) and Elsby and Michaels (2013). However, they do not explore the quit-layoff mechanism that is the focus of this paper (even in principle their models would accommodate the research question we ask). Our innovation is to use their framework as the most parsimonious basis to conduct our experiment: business cycles with and without the quit-layoff mechanisms. For that reason, the material below starts to depart more and more substantially from these existing investigations, and we cease to acknowledge that important prior work going forward.

3.3 The quit-layoff mechanism in the model

The quit-layoff mechanism is present in the optimality conditions above as the reader experiments with shifts in the quit rate $\gamma f(\theta)$—such as by shifting γ only for the incumbent cohort of the firm's workers, while leaving aggregate and future γ fixed. Hence, a firm experiencing more or fewer

Figure 5: Quits, layoffs and hires vs employment growth



Notes: This figure plots the model equivalent of "hockey-sticks", i.e., the hiring, layoff and quit rates as a function of net establishment employment growth for the steady state (solid lines) and a recession (dashed lines). The recession period is when unemployment reaches its peak in the baseline exercise in Section 4, where we hit the economy with a persistent negative aggregate productivity shock. The gray lines indicate 45-degree lines for reference. This figure echoes the logic already present in Figure 4 in Davis et al. (2012)—who, as we discuss in the main text, foresee the quit-layoff mechanism but do not actually explore it theoretically or empirically.

quits finds itself needing to adjust layoffs accordingly—with a one-to-one effect for a given $n' < \widetilde{n}$.

The mechanism can be illustrated visually in Figure 5 using model simulations, in a manner that builds on Figure 3—except now in the model experiment, in its current version, quits are positive but flat (rather than exhibiting the more subtle hockey stick patterns). The figure illustrates the fact that in recessions, as quit rates fall, the layoff rate gradient shifts to the right. In fact, this figure is echoes a logic already present in Figure 4 in Davis et al. (2012)—*who foresee the quit-layoff mechanism but do not actually explore it theoretically or empirically*.[5]

3.4 Equilibrium and calibration

As we will study the perfect foresight transition dynamics of our model in response to aggregate shocks, we primarily focus on the definition of the stationary equilibrium of the model and omit

[5]Specifically, Davis et al. (2012) write:

> There are several ways to relax the iron link feature of MP-style models. If we exogenously vary the quit rate in the CHW model, we obtain the implications shown in Fig. 4. As the quit rate varies, the kink point moves and the layoff and hires relations shift accordingly. Specifically, a fall in the quit rate from [...] causes the cross-sectional hiring and layoff relations to shift rightward. That is, the fall in the quit rate creates an environment where employers require fewer hires when expanding and more layoffs when contracting to achieve a given growth rate. More generally, if the quit rate varies systematically with labor market slack, then so do the cross-sectional relations for hires and layoffs. This insight applies in more complex models as well. (p.5)

However, while the authors appear to informally suggest such an exercise in this portion, they do not conduct it formally or quantitatively (in the model or empirically). The remainder of their paper sidesteps quits and their effect on layoffs and is instead devoted to exploring the explanatory power of hockey sticks for the turnover outcomes, but not their interaction—which is the focus of our paper. We have carefully reviewed that paper, and the related literature and have, to our surprise, not found a theoretical or empirical treatment of the quit-layoff connection—with our paper aspiring to fill that gap.

the aggregate state s in the equilibrium objects below.

Stationary equilibrium. A stationary equilibrium of the model is a set of labor market tightness θ, hiring and layoff thresholds $R_n^h(x)$, $R_n^l(x)$, and marginal profit function $\Pi_n(x, n)$ such that:

- The hiring and layoff cutoffs $R_n^h(x)$, $R_n^l(x)$ satisfy the FOCs in Equations (21) and (22).
- Labor market tightness θ is consistent with the choices that firms make according to the policy function in Equation (23) and the evolution of the exogenous state variable x.
- The marginal profit function satisfies Equation (24).

We provide further details on how we solve for the steady-state of the model and simulate its transition dynamics in response to aggregate shocks in Appendix A..

Calibration. We closely follow the calibration strategy in Fujita and Nakajima (2016). A model period corresponds to a month. We set some parameters outside of the model, and jointly estimate the rest to target a set of empirical data moments. Table 1 summarizes these parameters and their values.

We assume that firm's idiosyncratic productivity follows an AR(1) process in logs:

$$\log(x_{t+1}) = \rho_x \log(x_t) + \sigma_x \varepsilon_{t+1}, \tag{25}$$

where ρ_x and σ_x capture the persistence and standard deviation of productivity, and $\varepsilon_t \overset{\text{i.i.d}}{\sim} N(0, 1)$.

We set the firm discount factor to $\beta = 0.996$, which implies an annual real interest rate of about 5 percent. We set the elasticity parameter in the CES matching function to $\eta = 1.6$ as in Schaal (2017). We set the curvature of the firm's production function to $\alpha = 0.72$ and fix the persistence of the idiosyncratic productivity process to $\rho_x = 0.95$.

We discuss each of the endogenously set parameters in the context of the data target which closely identifies it. However, all these parameters are jointly estimated to simultaneously match those targets. We target a monthly unemployment-to-employment transition probability of 25% in the CPS to discipline the vacancy creation cost $\kappa = 0.165$. We target an employment-to-unemployment separation probability of 1.5% to estimate $b = 0.354$. We note that matching these two targets implies a steady-state unemployment rate of $u = 0.015/(0.015 + 0.25) = 0.057$. To discipline the standard deviation of the idiosyncratic productivity process, we target the standard deviation of employment-weighted annual employment growth rate of 0.6 in the data and estimate $\sigma_x = 0.063$. Given that the model quit rate is $\gamma f(\theta)$ and that we target a monthly job finding rate of $f(\theta) = 0.25$ in steady state, we set $\gamma = 0.1$ to match the employer-to-employer transition probability of 2.5% in the CPS. To discipline the size of the labor force, we target a mean establishment size of 15 workers (mirroring the logic in Fujita and Nakajima, 2016). Given that the mass of firms is normalized to one, this implies an employment level of 15 as well in the model. Thus, we set $L = 15/(1 - u) = 15.9$.

Table 1: Parameter values

Parameter	Description	Value	Target/Source	Data	Model
			Pre-determined		
β	Discount factor	0.996			
λ	Shape of matching function	1.6			
α	Curvature of production function	0.72			
ρ_x	Persistence of idio. productivity	0.95			
			Estimated		
κ	Vacancy posting cost	0.165	UE rate (CPS)	0.25	0.25
b	UI benefit	0.354	EU rate (CPS)	0.015	0.015
σ_x	Std. dev. of idio. productivity	0.063	Std. dev. of ann. net emp. growth (Davis et. al, 2007, LBD)	0.6	0.6
γ	OJS efficiency	0.1	EE rate (CPS)	0.025	0.025
L	Labor force size	15.9	Mean establishment size (Henly and Sanhez, 2009)	15	15

Notes: This table summarizes the parameter values used in the steady-state calibration of the model.

4 Quantitative exercises: recessions with and without the quit-layoff mechanism

In this section, we use our model as a laboratory to study the role of worker quits in shaping firms' layoff decisions. Our goal is to explore how a recession plays out with and without the quit-layoff mechanism. The logic is as follow: an aggregate negative productivity leads firms to want to reduce employment. They cut hiring and increasingly rely on separations—quits and layoffs. But quits plummet during the recession as hiring falls. These "missing" quits amplify the spike in layoffs because they reduce the natural churn in firms. We find that a substantial share of layoffs in recessions is due to the decline in quits.

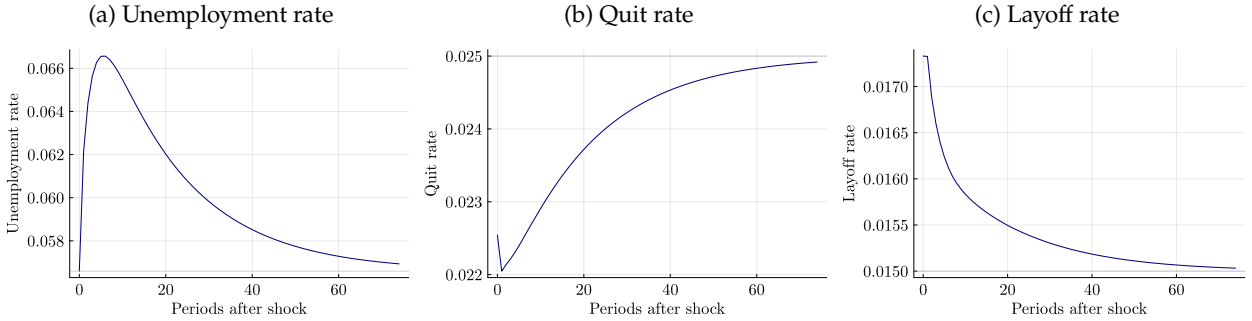
The aggregate shock. To this end, we simulate the model's response to a persistent negative aggregate productivity shock and study its perfect foresight transition dynamics.[6] More specifically, we assume that aggregate productivity z follows an AR(1) process in logs:

$$\log(z_{t+1}) = \rho_z \log(z) + \sigma_z \varepsilon_{t+1}, \tag{26}$$

where $\rho_z \in (0,1)$ is the persistence, $\sigma_z > 0$ is the standard deviation of the stochastic process and $\varepsilon_t \overset{\text{i.i.d}}{\sim} N(0,1)$. Throughout, we maintain $\rho_z = 0.95$ and $\sigma_z = 0.03$. We assume that at $t = 0$ the economy is in steady state and we hit the economy with a one-time two-standard deviation negative productivity shock at $t = 1$, after which z evolves according to Equation (26) with no other unexpected shock is realized to emulate a recession. We further assume that the economy returns to its initial steady state by $T = 250$ and ex-post verify that this horizon is long enough for the effects of the aggregate shock to have died out.

[6]We elaborate how we simulate the model in response to aggregate shocks in Appendix A., using a shooting algorithm.

Figure 6: Impulse responses to a negative aggregate productivity shock



Notes: This figure plots the impulse responses of the unemployment rate, quit rate and layoff rate to a persistent negative aggregate productivity shock.

Baseline: Negative aggregate productivity shock. We start by presenting impulse responses of labor-market outcomes to this negative aggregate productivity shock in Figure 6. Panel (a) shows that unemployment increases in response to the negative productivity shock.

Firms' desired employment shrinks, so that they reduce hiring and implement layoffs. This leads to labor market tightness to decline, which directly implies that the job finding rate falls—and along with that, quits, whose behavior tracks the job finding rate adjusted for γ (Panel (b)). That is, the quit rate, $\gamma f(\theta)$, shrinks in a recession. Firms also lay off workers in a recession, as shown in Panel (c).

In summary, the increase in unemployment comes about by both a decline in hiring and an increase in layoffs. We conclude that the model captures the broad contours of stylized facts of business cycles *qualitatively* (quantitative realism is work in progress).

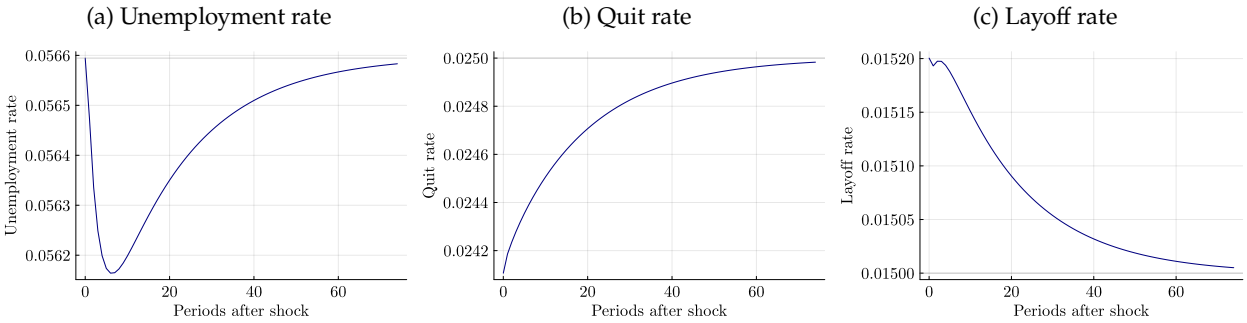
Negative OJS efficiency shock. To pinpoint the role of the quit-layoff mechanism in these business cycle patterns, we now implement a stepping-stone experiment that highlights the role of the decline in the quit rate in shaping layoffs in this model. Specifically, we instead consider a negative shock to the OJS efficiency parameter γ, which we assume returns back to its calibrated value following $\gamma_t = (1 - \rho_\gamma)\gamma_{\text{calib.}} + \rho_\gamma \gamma_{t-1}$ over time.

Figure 7 mirrors Figure 6 in plotting impulse responses of the unemployment, quit and layoff rates, but now for the quit shock rather than a productivity shock. Panel (a) shows that as OJS becomes less effective, the unemployed job seekers are crowded in, resulting in a decline in the unemployment rate.

Turning to quits as such, on net, Panel (b) shows that the decline in γ leads to a decline in the quit rate, $\gamma f(\theta)$, despite *labor market tightness being elevated* along the transition path (not shown).

The crucial illustration of our mechanism juxtaposes the quit rate evolution with the layoff rate response. Panel (c) shows that *this surgically induced decrease in quits leads to a surge in layoffs*, as shrinking firms now have to resort to layoffs instead of being able to rely on quits to reduce employment. Hence, the model confirms that a reduction in quits entails a nearly tantamount

Figure 7: Impulse responses to a negative on-the-job search efficiency shock



Notes: This figure plots the impulse responses of the unemployment rate, quit rate and layoff rate to a persistent negative on-the-job search efficiency shock.

increase in layoffs in a labor market equilibrium. Quantitatively, the "pass through" is about half.

Counterfactuals. Having established that our model captures the dynamics of the labor market qualitatively, we now turn to studying the cyclical role of the quit-layoff mechanism. To understand the link, we investigate the following counterfactual: we let quit rates remain at the steady state level, and check how this change transmits into the labor market, and specifically the layoff decisions at shrinking firms and at the aggregate level.

To dissect the effect, we consider three complementary exercises to gauge how quits cause layoffs. We present these results in Figure 8. All the panels include the layoff rate in the baseline economy for comparison and present the IRFs as deviations from steady state.[7]

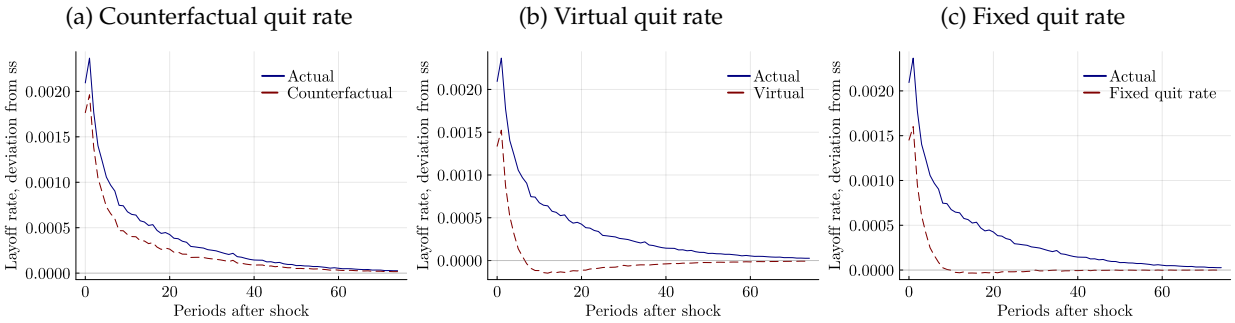
Our first exercise, in Panel (a), is based on an accounting identity and the assumption that layoffs and quits are perfect substitute for a firm—mirroring our empirical counterfactual. Panel (a) shows that the counterfactual layoff rate lies lower than the baseline economy. This suggests that in a recession if quit rate remained at its steady-state value, firms would have laid off considerably fewer workers during the recession.

In the second exercise, in Panel (b), we build on the first exercise, but this time endogenize firm responses to a world where firms (wrongly) assume that the quit rate stays at steady state during the transition. More specifically, we resolve the system of Equations (21)–(24) while keeping the quit rate $\gamma f(\theta)$ at its steady-state value, but assume the firm correctly forecasts the evolution of all other aggregate variables in the transition. In other words, the firm uses the correct policy function except that it assumes its own workers quit at the steady-state rate.[8] For this exercise, we neutralize equilibrium effects by assuming that the segment of such naive firms is small, so that the aggregate equilibrium is not affected by the firms operating on the virtual quit rate. Panel

[7]Because these IRFs involve stochastic firm-level simulations, we also generate a "ghost" transition path where we set the aggregate shock to 0, and treat this path as the steady state. This allows us to minimize errors arising from simulating only a finite number of firms.

[8]While doing so, we also iterate on the firm-level counterfactual employment level implied by this "wrong" policy function in generating IRFs.

Figure 8: Impulse response functions: layoffs in baseline vs counterfactuals



Notes: We note that the IRFs in this figure display some jaggedness arising from the stochastic simulations of firms.

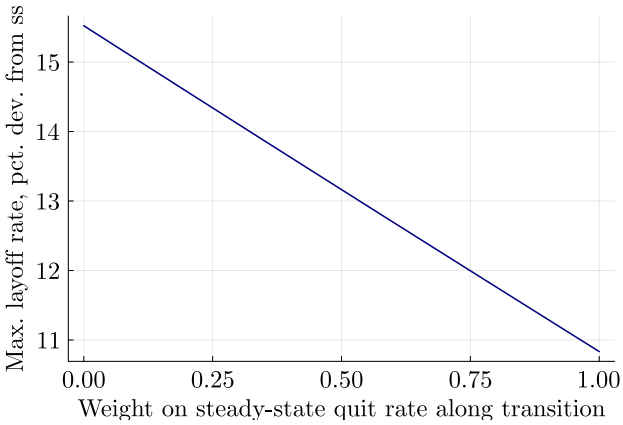
(b) shows that, corroborating the findings in Panel (a), the layoff rate is much lower than in the baseline, suggesting that a lack of quits cause heightened layoffs in a recession. The effect is much stronger than in Panel (a) because firms also make dynamic decisions, and now do not rely on layoffs thinking that future quit rates permit the adjustment.

In the third exercise, finally, we move away from micro-level firm behavior to accounting for general equilibrium effects as well. In particular, we solve for an equilibrium path of labor market tightness while ensuring that the aggregate quit rate remains flat at its steady-state value by adjusting the OJS efficiency properly. More specifically, we choose the path of search efficiency such that $\gamma_t = \gamma_{ss} f(\theta_{ss})/f(\theta_t)$, where θ_t is the equilibrium path tightness. Panel (c) shows that, again, the layoff rate lies below the baseline layoff rate in a world where quits do not shrink in recession.

Our counterfactual can also be conducted at a less extreme level to show how varying degrees of quit procyclicalities affect the layoff spike, for now again within the same model exercise. Figure 9 illustrates this approach by having the OJS efficiency parameter be chosen to deliver actual quit fluctuations to vary between full acyclicality and the full procyclicality. Concretely, it plots the maximum layoff rate as a function of the cyclicality of the quit rate along the transition path in response to a negative aggregate productivity shock. In particular, the exercise feeds in $q_t = \omega q_{ss} + (1-\omega) q_t^{\text{base.}}$ as the target quit rate to discipline γ_t and traces out how the maximum layoff rate changes as the weight moves from $\omega = 0$ (baseline quit rate path along the transition) all the way to $\omega = 1$ (adjusting γ to target a flat quit rate along the transition as in Figure 8 Panel (c)). The exercise accounts for equilibrium adjustments given a target quit rate path. The clearly downward sloping line illustrates the tight link between quit procyclicality and layoff countercyclicality—our mechanism in action.

We conclude that the totality of the results from these three exercises suggests that the collapse in quits in a recession cause an increase in layoffs—in that the surge in layoffs would have been considerably attenuated if quits had stayed stable.

Figure 9: Layoff amplification vs the cyclicality of quits



Notes: This figure plots the maximum layoff rate as a function of the cyclicality of the quit rate along the transition path in response to a negative aggregate productivity shock. In particular, the exercise feeds in $q_t = \omega q_{ss} + (1-\omega)q_t^{\text{base.}}$ as the target quit rate to discipline γ_t and traces out how the maximum layoff rate changes as the weight moves from $\omega = 0$ (baseline quit rate path along the transition) all the way to $\omega = 1$ (adjusting γ to target a flat quit rate along the transition).

5 Conclusion

We have explored a simple proximate cause of the spike in layoffs that characterizes recessions: the contemporaneous decline in quits. The economics is simple, obvious, and almost mechanical: quits and layoffs are substitutes in shrinking firms, so that one additional quit prevents one layoff. Hence, the decline in quits accounts for much of the increase in layoffs in recessions in the following sense: had quits stayed stable in recessions, a large share of the surge in layoffs would not have been implemented. We have quantified this quit-layoff link in aggregate time series, industry data, and firm level micro data—and found substantial potential power of the mechanism in explaining the increase in layoffs during recessions, currently focusing on the case study of the Great Recession, for which complete JOLTS data are available. We have formalized this channel in an equilibrium search model with multi-worker firms and explored its equilibrium transmission.

The next version of this paper will generalize the empirical investigation to a broader time series context, expand the model to a richer notion of layoff adjustment decisions (e.g., firing costs) and less stark division of labor between the turnover margins within the establishment. We also plan to explore the impact of labor market policies and stabilization policies on labor market outcomes in our model, which recognizes that layoffs and quits can be viewed as substitutes in many (shrinking) firms during recessions.

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A. Quantitative details

Steady-state equilibrium. Here, we describe the algorithm to solve for the steady-state equilibrium defined in Section 3.4.

0. Start with a guess of labor market tightness θ.

1. Given a guess of the expected marginal profit function $D(x, n, s)$, use FOCs in Equations (21) and (22) to solve for the hiring and layoff reservation thresholds $R_n^h(x, s)$ and $R_n^l(h, s)$.

2. Using the envelope condition in Equation (24), update the expected marginal profit function in Equation (20). If the guessed and updated expected marginal profits are close enough, continue to the next step. Otherwise, go back to step 1 to iterate until convergence.

3. Using the firm employment policy function in Equation (23) and the exogenous process for idiosyncratic productivity x, compute the ergodic distribution of firms $d(x, n)$ over the state space. In practice, we discretize the employment policy function and the stochastic process for productivity to construct a transition matrix to compute the stationary distribution.

4. Compute the implied labor market tightness as $\widetilde{\theta} = V/S$, where

$$V = \frac{1}{q(\theta)} \int_{x,n} \max\{n'(x, n) - (1 - \gamma f(\theta))n, 0\} d(x, n) dx dn \tag{A1}$$

   is the total mass of vacancies posted by hiring firms and

$$S = L \cdot (\gamma(1 - u) + u) \tag{A2}$$

   is the aggregate search effort, including employed and unemployed job seekers. Here u is the steady-state unemployment rate $u = \delta/(\delta + f(\theta))$, where δ is the average layoff rate that can be computed using the transition matrix in Step 3.

5. Check if $\widetilde{\theta}$ is close enough to θ. If yes, stop. Otherwise, update labor market tightness to $\theta^{\text{new}} = \omega\theta + (1 - \omega)\widetilde{\theta}$ and go back to step 0 to iterate until convergence. We use a dampening parameter of $\omega = 0.5$ as the current iteration's θ weight to update next period's guess.

Transition dynamics. We use a shooting algorithm to study the perfect-foresight transition dynamics of our model. We assume that the economy rests at steady state as of period $t = 0$, and in period $t = 1$ the economy is hit with an aggregate shock. The firms and workers are surprised by this shock and yet they do not expect any other shock to hit the economy after its realization. We consider transitory (but persistent) shocks and assume that the economy's transition is completed by $t = T$. We ex-post verify that T is long enough for the economy to have returned to its initial steady state. In the notation below, t-subscripts encode the dependence of the equilibrium objects on the aggregate state s. We now turn to describing the algorithm.

0. Fix the path of the exogenous shock over $t = 1, \cdots, T$, e.g., aggregate productivity z_t.

1. Guess the path of labor market tightness θ_t.

2. Use Equations (21), (22) and (24) to iterate on the hiring and layoff reservation threshold $R^h_{n,t}(x, s)$, $R^l_{n,t}(h, s)$, and expected marginal profit function $D_t(x, n)$ paths *backwards*, starting from the terminal steady state at $t = T + 1$.

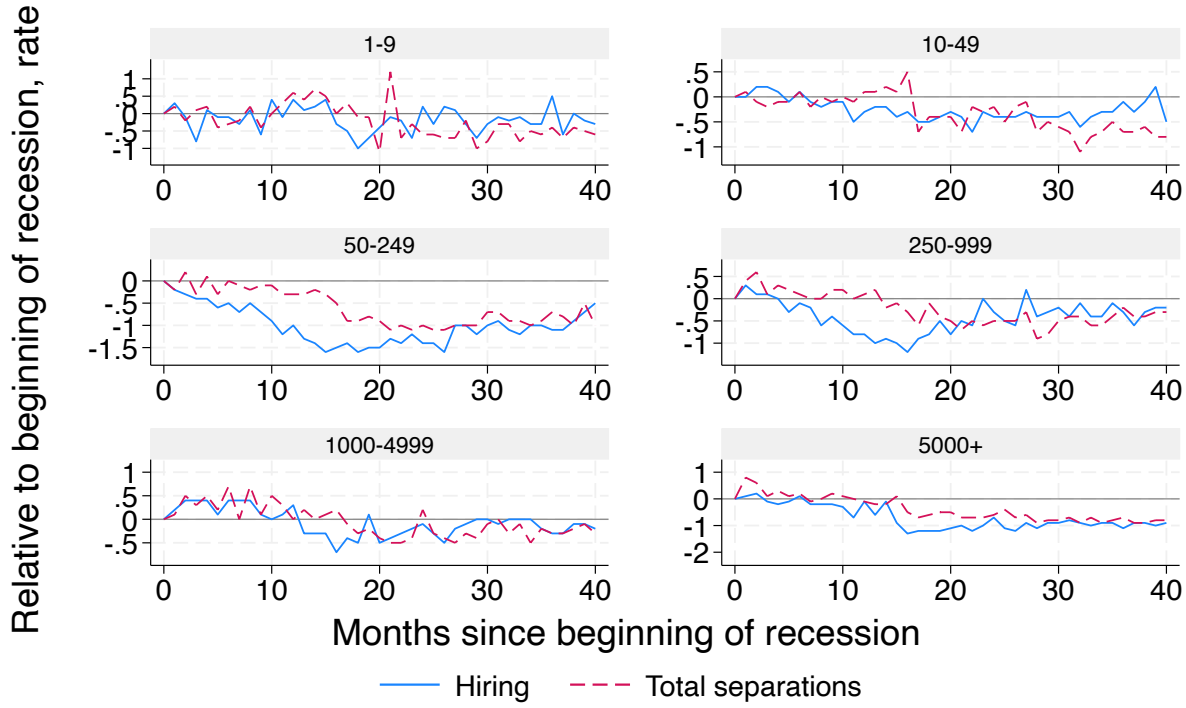
3. Using the firm employment policy function in Equation (23) and the exogenous process for idiosyncratic productivity x, iterate on the worker distribution *forward*, starting from the initial ergodic distribution at $t = 0$.

4. Compute the implied labor market tightness as $\widetilde{\theta}_t = V_t / S_t$, where V_t and S_t can be calculated period-by-period using the transition matrix, which itself is recomputed for each period using the path of the policy functions.

5. Check if $\widetilde{\theta}_t$ is close enough to θ_t. If yes, stop. Otherwise, update the guess of the labor market tightness path to $\theta_t^{\text{new}} = \omega\theta_t + (1 - \omega)\widetilde{\theta}_t$ and go back to step 1 to iterate until convergence. In practice we use a dampening parameter of $\omega = 0.95$ for numerical stability.

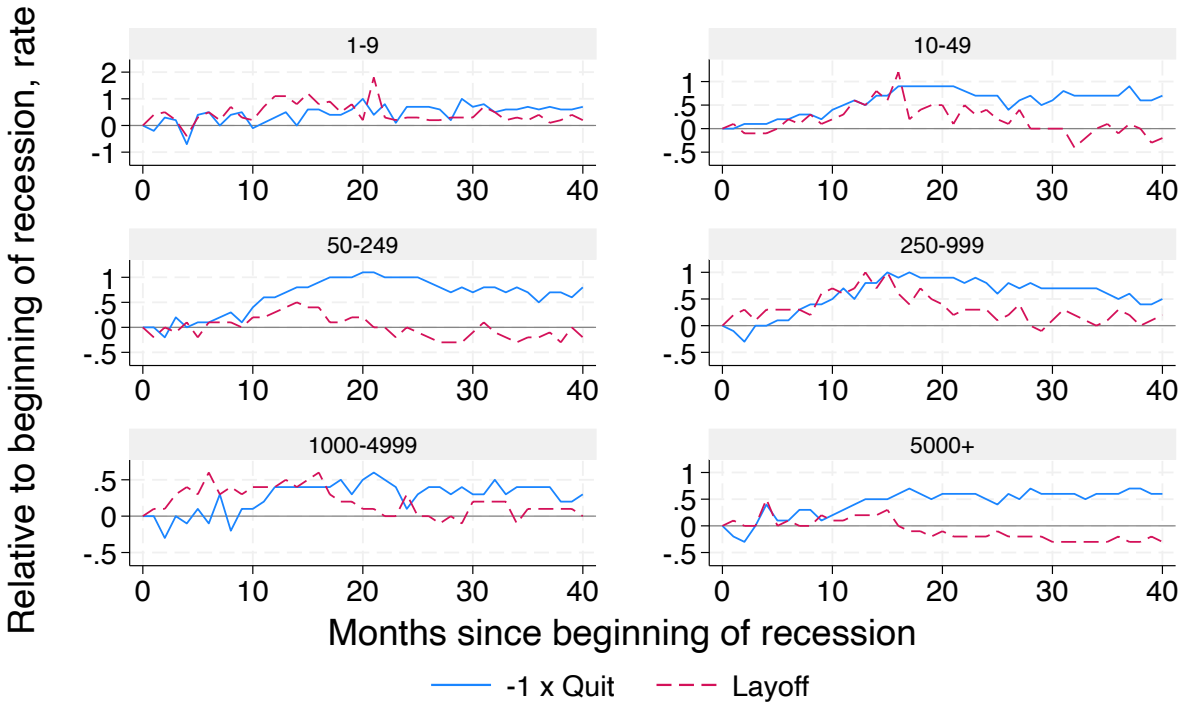
B. Additional figures

Figure A1: Hiring and separations dynamics during the Great Recession by establishment size



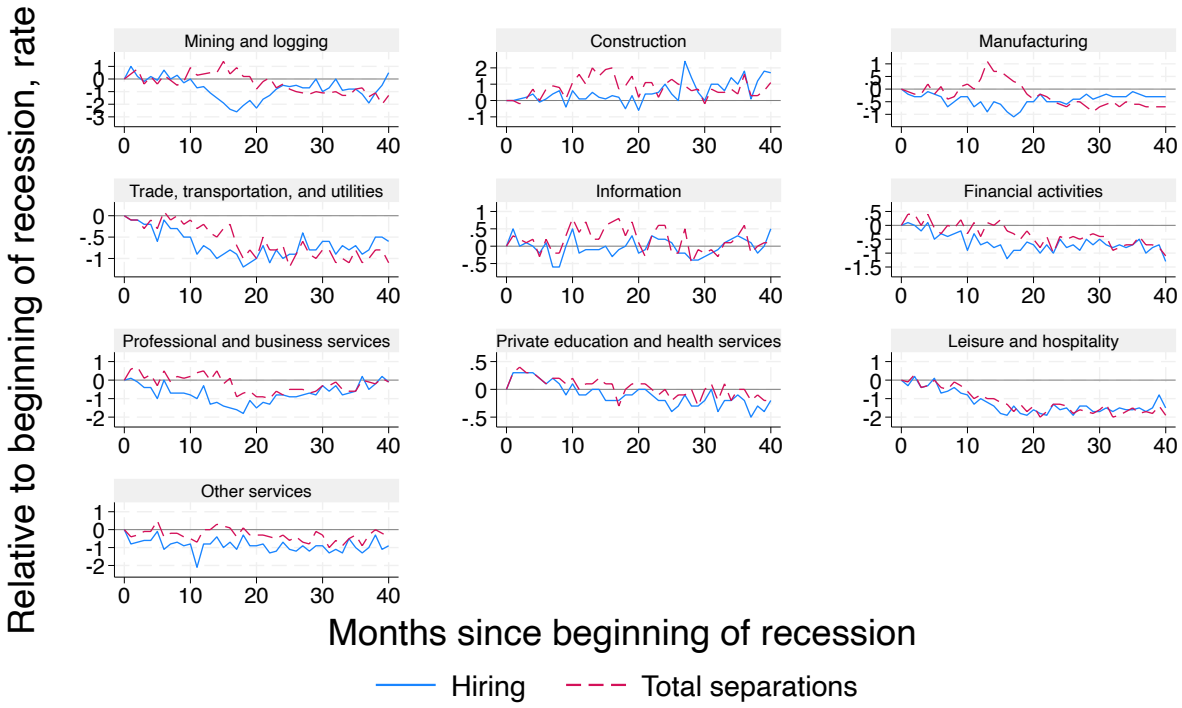
Notes: This figure plots hiring rate and total separation rate dynamics relative to the beginning of the Great Recession by establishment size categories.

Figure A2: Quit and layoff dynamics during the Great Recession by establishment size



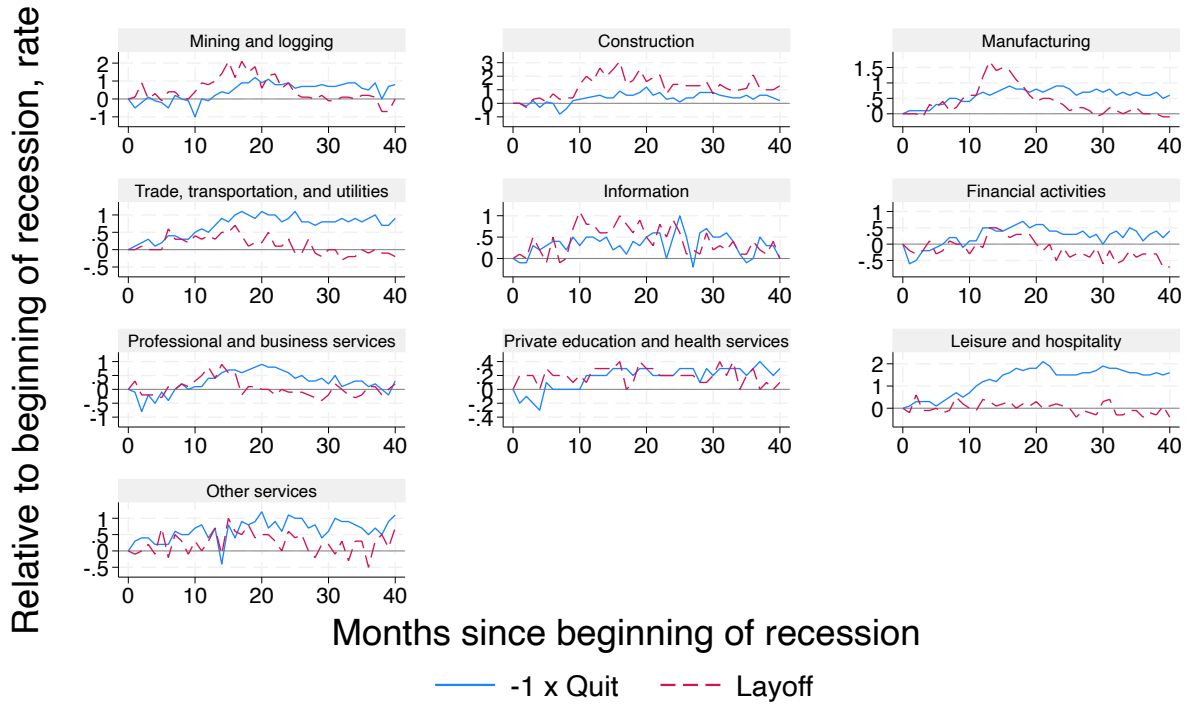
Notes: This figure plots quit rate (multiplied by -1) and layoff rate dynamics relative to the beginning of the Great Recession by establishment size categories.

Figure A3: Hiring and separations dynamics during the Great Recession by industry



Notes: This figure plots hiring rate and separations rate dynamics relative to the beginning of the Great Recession by industries.

Figure A4: Quit and layoff dynamics during the Great Recession by industry



Notes: This figure plots quit rate (multiplied by -1) and layoff rate dynamics relative to the beginning of the Great Recession by industries.