Supplemental Appendix: Temporary Layoffs, Firm Entry and Exit Dynamics, and Aggregate Fluctuations

By Sanjay K. Chugh and Alan Finkelstein Shapiro*

Online Appendix

Data Details and Additional Empirical Facts

B1. Data Details

Real GDP. — Real Gross Domestic Product, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate. Source: Saint Louis Federal Reserve Economic Data (FRED) Database. Time span used: 1992Q3-2019Q3.

Unemployment Rate. — Unemployment Rate, Percent, Quarterly, Seasonally Adjusted. Source: Saint Louis Federal Reserve Economic Data (FRED) Database. Time span used: 1992Q3-2019Q3.

Temporary Layoffs as a Share of Total Unemployment. — Job Losers on Layoff as a Percent of Total Unemployed, Percent, Quarterly, Seasonally Adjusted. Source: Saint Louis Federal Reserve Economic Data (FRED) Database. Time span used: 1992Q3-2019Q3. See Figure B1 for the time series from 1990Q1-2019Q3 and 1990Q1-2020Q3, where the latter time span includes the onset of the COVID-19 pandemic.

Temporary Layoffs (Level). — Unemployment Level - Job Losers on Layoff, Thousands of Persons, Quarterly, Seasonally Adjusted. Source: Saint Louis Federal Reserve Economic Data (FRED) Database. Time span used: 1992Q3-2019Q3.

* Chugh: Department of Economics, The Ohio State University, 1945 N. High Street, #410, Columbus, OH 43210. Finkelstein Shapiro: Department of Economics, Tufts University, Joyce Cummings Center, 177 College Ave., Medford, MA 02155. Alan.Finkelstein_Shapiro@tufts.edu. Sanjay Chugh tragically passed away on December 13, 2022. This paper is dedicated to him and to his passion for macro-labor and economics more broadly. I thank the editor Ayşegül Şahin and two anonymous reviewers for very useful comments and suggestions, and Victoria Nuguer, Fabio Ghironi, Chris Papageorgiou, Robert Zymek, and seminar participants at the University of Washington, the IMF Research Department, and the 4th CRC TR 224 Workshop on Labor Markets for very useful feedback. Any errors are my own.

Establishment Births. — Number of Establishment Births, Private Industry, All Firm Size Classes, Quarterly. Seasonally Adjusted. Source: Bureau of Labor Statistics Business Employment Dynamics. Time span used: 1992Q3-2019Q3.

Establishment Death Rate. — Establishment deaths as a share of the average total number of establishments over the previous and current period, Private Industry, All Firm Size Classes, Quarterly. Seasonally Adjusted. Source: Bureau of Labor Statistics Business Employment Dynamics. Time span used: 1992Q3-2019Q3.

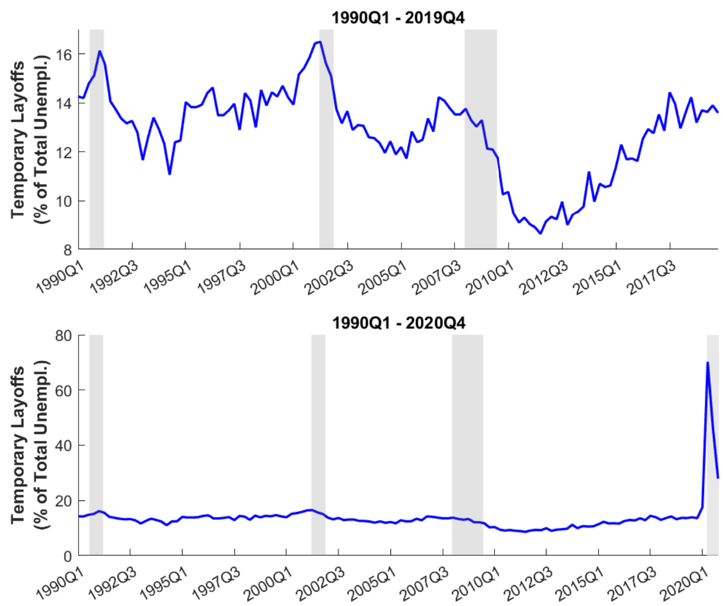
Firm Survival Rate. — Computed as one minus the Establishment Death Rate.

Vacancies. — Total Private Job Openings (Levels, Thousands of persons), Quarterly. Seasonally Adjusted. Source: Saint Louis Federal Reserve Economic Data (FRED) Database. Time span used: 2001Q1-2019Q3.

Market Tightness. — Constructed as the ratio of Total Private Job Openings (Level, Thousands of persons) and Total Unemployment (Level, Thousands of persons, from the Saint Louis Federal Reserve Economic Data (FRED) Database) using quarterly seasonally adjusted data. Two time spans used: 2001Q1-2019Q3 (JOLTS only) and 1992Q3-2019Q3 (merged JOLTS and Barnichon Help Wanted Index).

B2. Additional Empirical Facts

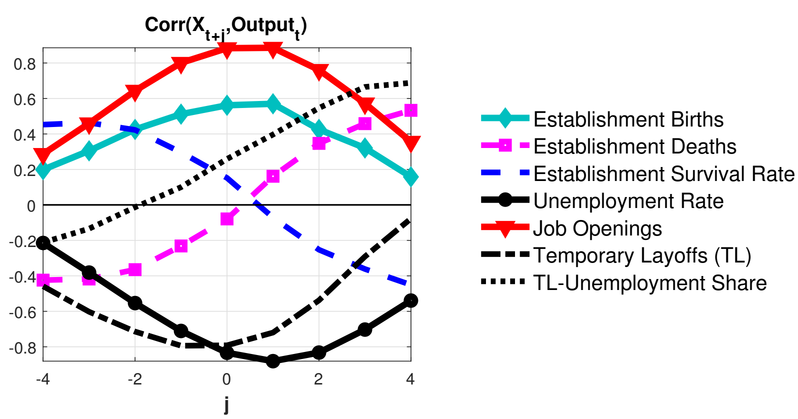
Figure B1. Temporary Layoffs as a Share of Total Unemployment, 1990Q1-2019Q3 (Top Figure) and 1990Q1-2020Q4 (Bottom Figure, Includes the COVID-19 Pandemic)



Note: The series are seasonally adjusted.
Source: Saint Louis FRED Database.

Table B1—Aggregate Unemployment, Temporary Layoffs, Firm Births, and Firm Deaths Over the U.S. Business Cycle (1992Q3-2019Q3).

	Standard Dev. (SD) Rel. to SD of GDP	**Contemporaneous Correl. with GDP**	**Autocorrelation**
Unempl. Rate	11.34	-0.834	0.943
Temp. Layoffs (TL)	9.20	-0.792	0.769
TL-Unempl. Share	6.60	0.259	0.654
Job Openings	11.87	0.883	0.914
Establishment Births	3.37	0.561	0.381
Establishment Deaths	4.24	-0.08	0.527
Estab. Survival Rate	0.12	0.152	0.489



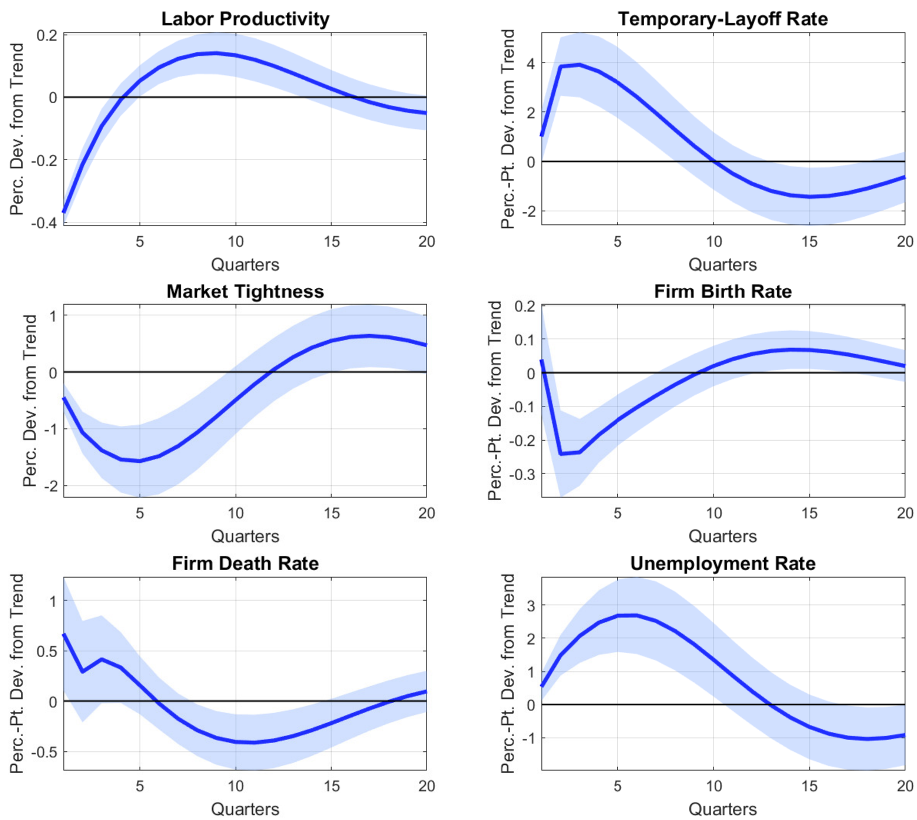
Note: Unempl. Rate is the civilian unemployment rate, Temp. Layoffs (TL) is the number of individuals on temporary layoff, and the TL-Unempl. Share is the share of temporary layoffs in total unemployment. The establishment (estab.) survival rate is computed as 1 minus the establishment death rate using data from the BLS Business Employment Dynamics database. The data used in this figure spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics) except for job openings from JOLTS, which spans 2001Q1-2019Q3 (similar (qualitative and quantitative) facts are observed for job openings if we merge the JOLTS data with the Barnichon Help Wanted Index to obtain a longer time series for job openings). See Appendix B.B1 for variable definitions, sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (except for variables expressed in rates) and a Hodrick-Prescott (HP) filter with smoothing parameter 1,600.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

TABLE B2—CORRELATION MATRIX BETWEEN FIRM BIRTHS, FIRM DEATHS, FIRM SURVIVAL RATE, TEMPORARY LAYOFFS, AND UNEMPLOYMENT: CYCLICAL SERIES.

	Estab. Births	**Estab. Deaths**	**Estab. Surv. Rate**	**Temporary Layoffs (TL)**	**TL-Unem. Share**	**Unempl. Rate**
Estab. Births	1	-0.175	0.214	-0.599	0.027	-0.565
		(0.094)	(0.094)	(0.077)	(0.096)	(0.079)
Estab. Deaths	–	1	-0.963	0.298	0.504	-0.081
			(0.026)	(0.091)	(0.083)	(0.096)
Estab. Surv. Rate	–	–	1	-0.371	-0.434	-0.043
				(0.089)	(0.086)	(0.096)
Temp. Layoffs	–	–	–	1	0.202	0.736
					(0.094)	(0.065)
TL-Unem. Share	–	–	–	–	1	-0.473
						(0.084)
Unempl. Rate	–	–	–	–	–	1

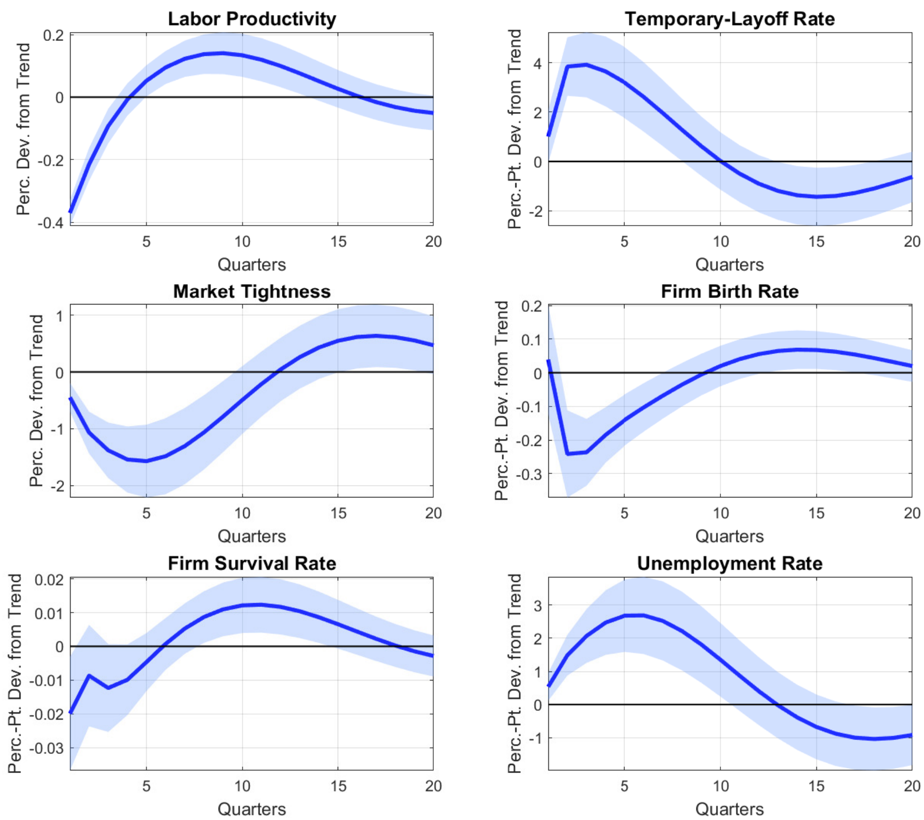
Note: The establishment (estab.) survival (surv.) rate is computed as 1 minus the establishment death rate using data from the BLS Business Employment Dynamics database. Unempl. Rate is the civilian unemployment rate, Temp. Layoffs (TL) is the number of individuals on temporary layoff, and the TL-Unempl. Share is the share of temporary layoffs in total unemployment. The data used spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics) except for job openings, which spans 2001Q1-2019Q3. See Appendix B.B1 for variable definitions, sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (except for variables expressed in rates) and a Hodrick-Prescott (HP) filter with smoothing parameter 1,600. Standard errors in parentheses. Similar facts hold if we use establishment-birth and temporary-layoff rates.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

Figure B2. Response of Temporary Layoffs, Firm Births, and Firm Deaths to a Negative One-Standard-Deviation Productivity Shock in U.S. Data (1992Q3-2019Q3), Temporary Layoffs, Firm Births, and Firm Deaths Expressed in Rates



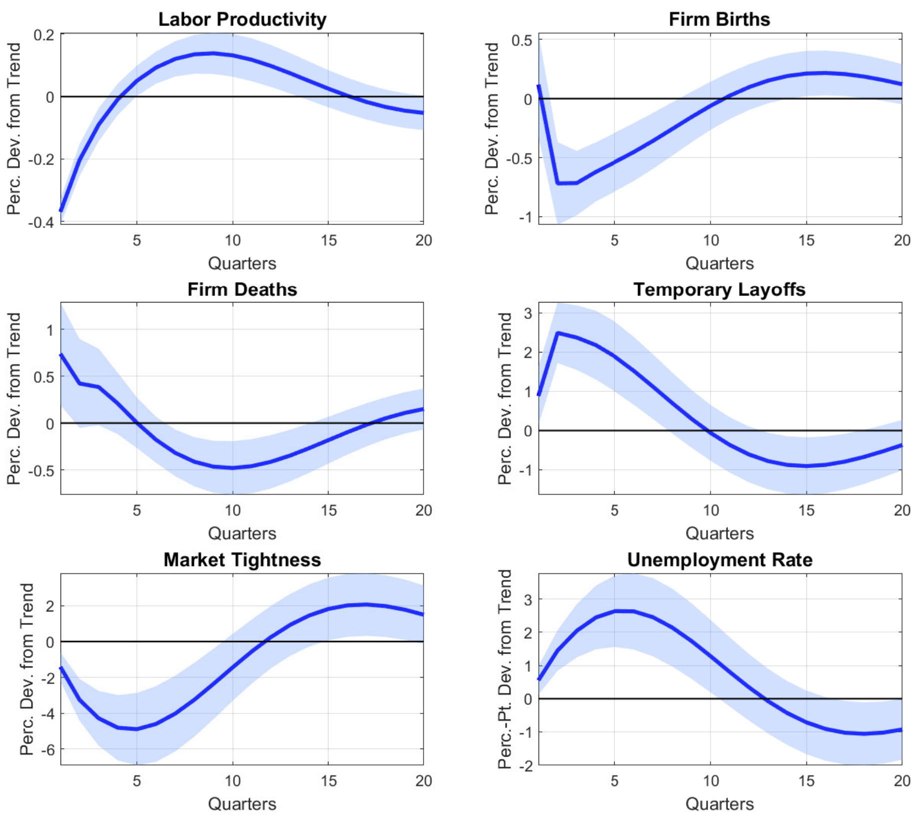
Note: The data used spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics). See Appendix B.B1 for variable definitions, sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (except for variables expressed in rates) and a Hodrick-Prescott (HP) filter with smoothing parameter 1,600. 90 percent confidence bands are shown in light blue. The ordering of the variables is: labor productivity, the temporary-layoff rate, market tightness, the firm birth rate, the firm death rate, and the unemployment rate.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

Figure B3. Response of Temporary Layoffs, Firm Births, and Firm Deaths to a Negative One-Standard-Deviation Productivity Shock in U.S. Data (1992Q3-2019Q3), Replacing Firm Death Rate with Firm Survival Rate



Note: The data used spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics). See Appendix B.B1 for variable definitions, sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (except for variables expressed in rates) and a Hodrick-Prescott (HP) filter with smoothing parameter 1,600. 90 percent confidence bands are shown in light blue. The ordering of the variables is: labor productivity, the temporary-layoff rate, market tightness, the firm birth rate, the firm survival rate, and the unemployment rate.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

Figure B4. Response of Temporary Layoffs, Firm Births, and Firm Deaths to a Negative One-Standard-Deviation Productivity Shock in U.S. Data (1992Q3-2019Q3), Alternative VAR Ordering



Note: The data used spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics). See Appendix B.B1 for variable definitions, sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (except for variables expressed in rates) and a Hodrick-Prescott (HP) filter with smoothing parameter 1,600. 90 percent confidence bands are shown in light blue. The ordering of the variables is: labor productivity, firm births, firm deaths, temporary layoffs, market tightness, and the unemployment rate.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

Additional Model Details

C1. Summary of Model Parameters and Endogenous Variables

Table C1—Benchmark Model Parameters

Parameter	Definition/Notes
e	Fixed cost associated with recruiting process Drawn from *i.i.d.* distribution $F(e)$
γ	Flow cost of vacancy posting
a	Saved resources from placing worker on temporary layoff Drawn from *i.i.d.* distribution $H(a)$
ζ	Fixed cost of recalling worker on temporary layoff back to firm Drawn from *i.i.d.* distribution $R(\zeta)$
ρ_n	Exogenous job separation probability
ρ_v	Exogenous rate of decay of unfilled vacancies
ρ_i	Exogenous probability that temporary layoff becomes permanent
χ_i	Benefits provided by firm to workers on temporary layoff
χ_u	Unemployment insurance benefits
f_E	Firm sunk entry cost
f_a	Firm fixed operating cost

Table C2—Endogenous Variables in Benchmark Model

Variable Name	**Definition/Notes**
z_{at}	Threshold level of idiosyncratic productivity
$\widetilde{z}_t$	Average idiosyncratic productivity among surviving firms
c_t	Consumption
n_{at}	Active employment
n_{it}	Workers on temporary layoff
s_t	Searchers
$\widetilde{y}_t$	Average output per active firm
Y_t	Total output
w_{nt}	Nash-bargained real wage
w_t	Real wage $w_t = (w^*)^{\gamma_w} (w_{nt})^{1-\gamma_w}$
$\mathbf{W}_{at}$	Net value to household of having a member in active employment
$\mathbf{W}_{it}$	Net value to household of having a member on temporary layoff
$\widetilde{d}_t$	Average individual-firm real profits
N_{Et}	Measure of new firm entrants
N_t	Measure of producing firms
$(1 - G(z_{at}))$	Endogenous firm survival rate
$\widetilde{\rho}_t$	Average price among surviving final-goods firms
mc_t	Real price of intermediate goods/marginal cost of final-goods firms
v_t	Total job vacancies
v_{nt}	New job vacancies
$\mathbf{J}_{at}$	Value of having an active worker for intermediate-goods firm
$\mathbf{J}_{it}$	Value of having an inactive worker for intermediate-goods firm
$\mathbf{J}_{vt}$	Value of a vacancy for intermediate-goods firm
$\widetilde{\zeta}_t$	Threshold level of ζ below which firm brings worker back from temporary layoff
$\widetilde{a}_t$	Threshold level of a below which firm places active worker on temporary layoff
q_{at}	Endogenous probability of temporary layoff
q_{rt}	Endogenous probability that firm brings worker back from temporary layoff

C2. Intermediate Goods Firms

This section provides the details behind the profit maximization problem of the representative firm in Section II.A of the main text.

Firm Profits and Evolution of Active Employment, Temporary Layoffs, and Vacancies. — Real profits of the representative intermediate goods firm in period t are given by

$$\begin{aligned}\Pi_t =& mc_t Z_t n_{at} - w_t n_{at} - \gamma v_t - \int_0^{\widetilde{e}_t} e dF(e) \\ &+ (1-\rho_n) n_{at-1}\left(\int_0^{\widetilde{a}_t} a dH(a)\right) - \chi_i n_{it} - (1-\rho_i) n_{it-1}\left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta)\right).\end{aligned}$$

The firm faces its perceived laws of motion for active employment

$$n_{at} = (1-\rho_n)(1-q_{at})n_{at-1} + v_t q_t + q_{rt}(1-\rho_i)n_{it-1}, \tag{C1}$$

workers on temporary layoff

$$n_{it} = (1-q_{rt})(1-\rho_i)n_{it-1} + q_{at}(1-\rho_n)n_{at-1}, \tag{C2}$$

and the evolution of total vacancies

$$v_t = (1-\rho_v)(1-q_{t-1})v_{t-1} + n_{at-1}\left(\rho_n + (1-\rho_n)q_{at}\right) + v_{nt}, \tag{C3}$$

where, for future reference, we can write new vacancies as a function of the endogenous threshold $\widetilde{e}_t$ as follows: $v_{nt} = F(\widetilde{e}_t)$ (see, for example, Leduc and Liu, 2020, 2023).

Intermediate Goods Firm Value Function. — Denoting the multipliers on the firm's perceived evolution of active employment n_{at}, workers on temporary layoff n_{it}, and total vacancies v_t by μ_{at}, μ_{it}, and μ_{vt}, respectively, we can write the intermediate goods firm value function $\mathbf{J}_t(n_{at-1}, n_{it-1}, v_{t-1}, Z_t)$ inclusive of the firm's perceived laws of motion for n_{at}, n_{it}, and v_t as

$$\mathbf{J}_t(n_{at-1}, n_{it-1}, v_{t-1}, Z_t) = \max_{\{n_{at}, n_{it}, v_t, \widetilde{a}_t, \widetilde{\zeta}_t, \widetilde{e}_t\}} \begin{bmatrix} mc_t Z_t n_{at} - w_t n_{at} - \gamma v_t - \int_0^{\widetilde{e}_t} e dF(e) \\ +(1-\rho_n) n_{at-1} \left(\int_0^{\widetilde{a}_t} a dH(a) \right) \\ -\chi_i n_{it} - (1-\rho_i) n_{it-1} \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) \right) \\ +E_t \Xi_{t+1|t} \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1}) \\ +\mu_{at}[(1-\rho_n)(1-q_{at}) n_{at-1} \\ +v_t q_t + q_{rt}(1-\rho_i) n_{it-1} - n_{at}] \\ +\mu_{it}[(1-q_{rt})(1-\rho_i) n_{it-1} \\ +q_{at}(1-\rho_n) n_{at-1} - n_{it}] \\ +\mu_{vt}[(1-\rho_v)(1-q_{t-1}) v_{t-1} \\ +n_{at-1}\left(\rho_n + (1-\rho_n) q_{at}\right) + F(\widetilde{e}_t) - v_t] \end{bmatrix}.$$

Firm Envelope Conditions, First-Order Conditions, and Value Expressions. —

First-Order Conditions. — First, consider the envelope conditions for the endogenous state variables n_{at-1}, n_{it-1}, and v_{t-1}:

$$\frac{\partial \mathbf{J}_t(n_{at-1}, n_{it-1}, v_{t-1}, Z_t)}{\partial n_{at-1}} = (1-\rho_n) \left(\mu_{at}(1-q_{at}) + \mu_{it} q_{at} + \int_0^{\widetilde{a}_t} a dH(a) \right) + \mu_{vt}\left(\rho_n + (1-\rho_n) q_{at}\right),$$

$$\frac{\partial \mathbf{J}_t(n_{at-1}, n_{it-1}, v_{t-1}, Z_t)}{\partial n_{it-1}} = (1-\rho_i) \left(\mu_{at} q_{rt} + \mu_{it}\left(1-q_{rt}\right) - \int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) \right),$$

and

$$\frac{\partial \mathbf{J}_t(n_{at-1}, n_{it-1}, v_{t-1}, Z_t)}{\partial v_{t-1}} = \mu_{vt}(1-\rho_v)\left(1-q_{t-1}\right).$$

With these conditions in mind, the firm's choices over active employment n_{at}, workers on temporary layoff n_{it}, and total vacancies are:

$$mc_t Z_t - w_t - \mu_{at} + E_t \Xi_{t+1|t} \frac{\partial \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1})}{\partial n_{at}} = 0,$$

$$-\chi_i - \mu_{it} + E_t \Xi_{t+1|t} \frac{\partial \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1})}{\partial n_{it}} = 0,$$

and

$$-\gamma + \mu_{at} q_t - \mu_{vt} + E_t \Xi_{t+1|t} \frac{\partial \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1})}{\partial v_t} = 0.$$

Turning to the first-order conditions with respect to the endogenous thresholds $\widetilde{a}_t, \widetilde{\zeta}_t$, and $\widetilde{e}_t$, note that the choice over $\widetilde{a}_t$ implies a choice over q_{at} since $q_{at} = H(\widetilde{a}_t)$. Moreover, since $q_{at} = H(\widetilde{a}_t)$, then $\partial q_{at}/\partial \widetilde{a}_t = \partial H(\widetilde{a}_t)/\partial \widetilde{a}_t = h(\widetilde{a}_t)$ (i.e., the pdf of H). Similarly, the choice over $\widetilde{\zeta}_t$ implies a choice over q_{rt} since $q_{rt} = R(\widetilde{\zeta}_t)$. Moreover, since $q_{rt} = R(\widetilde{\zeta}_t)$, then $\partial q_{rt}/\partial \widetilde{\zeta}_t = \partial R(\widetilde{\zeta}_t)/\partial \widetilde{\zeta}_t = r(\widetilde{\zeta}_t)$ (i.e., the pdf of R). Finally, remember from the main text that we can express new vacancies v_{nt} as a function of $\widetilde{e}_t$: $v_{nt} = F(\widetilde{e}_t)$. Then, the first-order condition with respect to $\widetilde{a}_t, \widetilde{\zeta}_t$, and $\widetilde{e}_t$, respectively, are:

$$\begin{aligned}(1-\rho_n)n_{at-1}\frac{\partial q_{at}}{\partial \widetilde{a}_t}\widetilde{a}_t - \mu_{at}(1-\rho_n)n_{at-1}\frac{\partial q_{at}}{\partial \widetilde{a}_t}&\\ + \mu_{it}(1-\rho_n)n_{at-1}\frac{\partial q_{at}}{\partial \widetilde{a}_t} + \mu_{vt}(1-\rho_n)n_{at-1}\frac{\partial q_{at}}{\partial \widetilde{a}_t} &= 0,\end{aligned}$$

$$-(1-\rho_i)n_{it-1}\frac{\partial q_{rt}}{\partial \widetilde{\zeta}_t}\widetilde{\zeta}_t + \mu_{at}(1-\rho_i)n_{it-1}\frac{\partial q_{rt}}{\partial \widetilde{\zeta}_t} - \mu_{it}(1-\rho_i)n_{it-1}\frac{\partial q_{rt}}{\partial \widetilde{\zeta}_t} = 0,$$

and

$$-\frac{\partial F(\widetilde{e}_t)}{\partial \widetilde{e}_t}\widetilde{e}_t + \mu_{vt}\frac{\partial F(\widetilde{e}_t)}{\partial \widetilde{e}_t} = 0.$$

Optimality Conditions. — Defining $\mu_{at} \equiv \mathbf{J}_{at}$, $\mu_{it} \equiv \mathbf{J}_{it}$, and $\mu_{vt} \equiv \mathbf{J}_{vt}$ as the period-t values to the firm of having an active worker, a worker on temporary layoff, and a vacancy, respectively, and using the envelope conditions derived above in $t+1$, we can write the optimality conditions for n_{at}, n_{it}, and v_t as:

$$\begin{aligned}\mathbf{J}_{at} &= mc_t Z_t - w_t + (1-\rho_n)E_t\left\{\Xi_{t+1|t}\left(1-q_{at+1}\right)\mathbf{J}_{at+1}\right\}\\ &+ (1-\rho_n)E_t\left\{\Xi_{t+1|t}\left(q_{at+1}\mathbf{J}_{it+1} + \int_0^{\widetilde{a}_{t+1}} a dH(a)\right)\right\}\\ &+ E_t\left\{\Xi_{t+1|t}\left(\rho_n + (1-\rho_n)q_{at+1}\right)\mathbf{J}_{vt+1}\right\},\end{aligned} \tag{C4}$$

$$\begin{aligned}\mathbf{J}_{it} &= -\chi_i + (1-\rho_i)E_t\left\{\Xi_{t+1|t}(1-q_{rt+1})\mathbf{J}_{it+1}\right\}\\ &+ (1-\rho_i)E_t\left\{\Xi_{t+1|t}\left(q_{rt+1}\mathbf{J}_{at+1} - \int_0^{\widetilde{\zeta}_{t+1}} \zeta dR(\zeta)\right)\right\},\end{aligned} \tag{C5}$$

and

$$\mathbf{J}_{vt} = -\gamma + q_t \mathbf{J}_{at} + (1-\rho_v)(1-q_t) E_t \left\{ \Xi_{t+1|t} \mathbf{J}_{vt+1} \right\}. \tag{C6}$$

In turn, we can write the optimality conditions for $\widetilde{a}_t, \widetilde{\zeta}_t$, and $\widetilde{e}_t$ as:

$$\widetilde{a}_t = \left(\mathbf{J}_{at} - \mathbf{J}_{it} - \mathbf{J}_{vt} \right), \tag{C7}$$

and

$$\widetilde{\zeta}_t = \left(\mathbf{J}_{at} - \mathbf{J}_{it} \right). \tag{C8}$$

and

$$\widetilde{e}_t = \mathbf{J}_{vt}. \tag{C9}$$

Given this last expression, it follows that we can express optimal new vacancies as $v_{n,t} = F\left(\widetilde{e}_t\right) = F\left(\mathbf{J}_{v,t}\right)$.

C3. Households

This section provides the details behind the optimality conditions of the representative household in Section II.C of the main text.

As stated in the main text, the representative household chooses state-contingent decision rules for consumption c_t, and mutual fund shares x_{t+1} for final-goods firms to maximize expected lifetime discounted utility $E_0 \sum_{t=0}^{\infty} \beta^t \mathbf{u}(c_t)$ subject to the budget constraint

(C10)
$$c_t + \mathbf{q}_t \left(N_t + N_{Et}\right) x_{t+1} + T_t = w_t n_{at} + \chi_u \left(\left(1 - f_t\right) s_t + n_{it}\right) + \chi_i n_{it} + \left(\widetilde{d}_t + \mathbf{q}_t\right) N_t x_t + \Pi_t.$$

To obtain the household value expressions, it proves useful to write the household's problem in recursive form.

Specifically, the value function of the household $V_t(n_{at-1}, n_{it-1}, N_{t-1}, x_t)$ is

$$V_t(n_{at-1}, n_{it-1}, N_{t-1}, x_t) = \max \left[\mathbf{u}(c_t) + \beta E_t V_{t+1}(n_{at}, n_{it}, N_t, x_{t+1})\right],$$

subject to the budget constraint (multiplier λ_t)

$$c_t + \mathbf{q}_t \left(N_t + N_{Et}\right) x_{t+1} + T_t = w_t n_{at} + \chi_u \left(\left(1 - f_t\right) s_t + n_{it}\right) + \chi_i n_{it} + \left(\widetilde{d}_t + \mathbf{q}_t\right) N_t x_t + \Pi_t$$

where the evolution of firms in period t is given by $N_t = \left(1 - G(z_{at})\right) N_{t-1} + N_{Et-1}$, the perceived law of motion for active employment (multiplier μ_{at})

$$n_{at} = (1 - \rho_n)(1 - q_{at})n_{at-1} + q_{rt}(1 - \rho_i)n_{it-1} + s_t f_t,$$

and the law of motion for inactive employment (multiplier μ_{it})

$$n_{it} = q_{at}(1 - \rho_n)n_{at-1} + (1 - q_{rt})(1 - \rho_i)n_{it-1},$$

where the measure of job searchers is

$$s_t = 1 - (1 - \rho_n)n_{at-1} - (1 - \rho_i)n_{it-1}.$$

The first-order conditions with respect to x_{t+1} can be written as

$$-\lambda_t \mathbf{q}_t \left(N_t + N_{Et}\right) + E_t \beta \lambda_{t+1} \left(\widetilde{d}_{t+1} + \mathbf{q}_{t+1}\right) N_{t+1} = 0.$$

Defining the stochastic discount factor as $\Xi_{t+1|t} \equiv \beta \lambda_{t+1} / \lambda_t$ and using the law of motion for N_t, we can write the firm creation condition as

$$\mathbf{q}_t = E_t \left\{\Xi_{t+1|t} \left(1 - G(z_{at+1})\right) \left(\widetilde{d}_{t+1} + \mathbf{q}_{t+1}\right)\right\}.$$

Using the fact that in equilibrium, $\mathbf{q}_t = f_{Et}$, the firm creation condition is:

$$f_{Et} = E_t \left\{ \Xi_{t+1|t} \left(1 - G(z_{at+1})\right) \left(\widetilde{d}_{t+1} + f_{Et+1} \right) \right\}. \tag{C11}$$

In turn, the first-order conditions with respect to n_{at} is

$$-\mu_{at} + \lambda_t \left(w_t - \chi_u\right) + E_t \beta \frac{\partial V_{t+1}(n_{at}, n_{it}, N_t, x_{t+1})}{\partial n_{at}} = 0,$$

and the first-order condition with respect to n_{it} is

$$-\mu_{it} + \lambda_t \chi_i + E_t \beta \frac{\partial V_{t+1}(n_{at}, n_{it}, N_t, x_{t+1})}{\partial n_{it}} = 0.$$

Using the definition of s_t, we can write the law of motion for active employment as

$$\begin{aligned} n_{at} &= (1-\rho_n)(1-q_{at})n_{at-1} + \left[1 - (1-\rho_n)n_{at-1} - (1-\rho_i)n_{it-1}\right] f_t + q_{rt}(1-\rho_i)n_{it-1} \\ &= (1-\rho_n)(1-q_{at})n_{at-1} - \left[(1-\rho_n)n_{at-1} + (1-\rho_i)n_{it-1}\right] f_t + f_t + q_{rt}(1-\rho_i)n_{it-1} \\ &= (1-\rho_n)n_{at-1}\left(1 - q_{at} - f_t\right) + (1-\rho_i)n_{it-1}\left(q_{rt} - f_t\right) + f_t. \end{aligned}$$

Then, the envelope condition with respect to n_{at-1} is

$$\frac{\partial V_t(n_{at-1}, n_{it-1}, N_{t-1}, x_t)}{\partial n_{at-1}} = \left(1-\rho_n\right)\left(1 - q_{at} - f_t\right)\mu_{at} + (1-\rho_n)q_{at}\mu_{it},$$

so that

$$\frac{\partial V_{t+1}(n_{at}, n_{it}, N_t, x_{t+1})}{\partial n_{at}} = \left(1-\rho_n\right)\left(1 - q_{at+1} - f_{t+1}\right)\mu_{at+1} + (1-\rho_n)q_{at+1}\mu_{it+1}.$$

Going back to first-order condition with respect to n_{at}, we can write

$$\begin{aligned} \mu_{at} = {} & \lambda_t \left(w_t - \chi_u\right) + E_t\beta\left[\left(1-\rho_n\right)\left(1 - q_{at+1} - f_{t+1}\right)\mu_{at+1}\right] \\ & + E_t\beta\left[(1-\rho_n)q_{at+1}\mu_{it+1}\right], \end{aligned}$$

or

$$\begin{aligned} \frac{\mu_{at}}{\lambda_t} = {} & w_t - \chi_u + E_t \frac{\beta\lambda_{t+1}}{\lambda_t}\left[\left(1-\rho_n\right)\left(1 - q_{at+1} - f_{t+1}\right)\frac{\mu_{at+1}}{\lambda_{t+1}}\right] \\ & + E_t \frac{\beta\lambda_{t+1}}{\lambda_t}\left[(1-\rho_n)q_{at+1}\frac{\mu_{it+1}}{\lambda_{t+1}}\right]. \end{aligned}$$

Defining $\mathbf{W}_{at} = (\mu_{at}/\lambda_t)$ and $\mathbf{W}_{it} = (\mu_{it}/\lambda_t)$ as the net values to the household from having an active worker and an inactive worker, respectively, the net value to the household from having a household member in active employment is

$$\mathbf{W}_{at} = w_t - \chi_u + (1-\rho_n)E_t\left\{\Xi_{t+1|t}\left(1 - q_{at+1} - f_{t+1}\right)\mathbf{W}_{at+1}\right\} \\ + (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\mathbf{W}_{it+1}\right\}.$$

Following similar steps, the envelope condition with respect to n_{it-1} is

$$\frac{\partial V_t(n_{at-1}, n_{it-1}, N_{t-1}, x_t)}{\partial n_{it-1}} = (1-\rho_i)\left(q_{rt} - f_t\right)\mu_{at} + (1-\rho_i)(1-q_{rt})\mu_{it},$$

so that

$$\frac{\partial V_{t+1}(n_{at}, n_{it}, N_t, x_{t+1})}{\partial n_{it}} = (1-\rho_i)\left(q_{rt+1} - f_{t+1}\right)\mu_{at+1} + (1-\rho_i)(1-q_{rt+1})\mu_{it+1}.$$

Then, going back to the first-order condition with respect to n_{it}, we can write

$$\mu_{it} = \lambda_t\left(\chi_i + \chi_u - \chi_u\right) + E_t\beta\left[(1-\rho_i)\left(q_{rt+1} - f_{t+1}\right)\mu_{at+1} + (1-\rho_i)(1-q_{rt+1})\mu_{it+1}\right],$$

or

$$\frac{\mu_{it}}{\lambda_t} = \chi_i + E_t\frac{\beta\lambda_{t+1}}{\lambda_t}\left[(1-\rho_i)\left(q_{rt+1} - f_{t+1}\right)\frac{\mu_{at+1}}{\lambda_{t+1}}\right] \\ + E_t\frac{\beta\lambda_{t+1}}{\lambda_t}\left[(1-\rho_i)\left(1 - q_{rt+1}\right)\frac{\mu_{it+1}}{\lambda_{t+1}}\right].$$

Finally, the net value to the household of having a household member on temporary layoff is

$$\mathbf{W}_{it} = \chi_i + (1-\rho_i)E_t\left\{\Xi_{t+1|t}\left(q_{rt+1} - f_{t+1}\right)\mathbf{W}_{at+1}\right\} \\ + (1-\rho_i)E_t\left\{\Xi_{t+1|t}\left(1 - q_{rt+1}\right)\mathbf{W}_{it+1}\right\}.$$

To understand the value expression $\mathbf{W}_{at}$, note that the contemporaneous value of having a household member in active employment in period t is given by the real wage w_t net of the value of unemployment benefits χ_u. Then, with probability $(1-\rho_n)$, the worker remains attached to the firm in period $t+1$, with net probability $(1 - q_{at+1} - f_{t+1})$, the worker remains in active employment in period $t+1$ and the household receives the value $\mathbf{W}_{at+1}$, and with probability q_{at+1} the worker is placed on temporary layoff in period $t+1$ and the household receives the value $\mathbf{W}_{it+1}$, where all $t+1$ elements are in expectation and discounted using $\Xi_{t+1|t}$.

Turning to the value expression $\mathbf{W}_{it}$, the contemporaneous value of having a household member on temporary layoff in period t is the transfer the worker receives from the firm, χ_i.[1] Then, with probability $(1-\rho_i)$, the worker remains attached to the firm in period $t+1$, with net probability $(q_{rt+1} - f_{t+1})$, the worker transitions to active employment in period $t+1$ and the household receives the value $\mathbf{W}_{at+1}$, and with probability $(1-q_{rt+1})$, the worker remains on temporary layoff in period $t+1$ and the household receives the value $\mathbf{W}_{it+1}$, where all $t+1$ elements are in expectation and discounted using $\Xi_{t+1|t}$.

[1]To understand the contemporaneous-value term in $\mathbf{W}_{it}$, note that $\mathbf{W}_{it}$ is the value to the household of having a household member on temporary layoff *net of having a member in search unemployment.* Moreover, recall that both individuals who are actively searching for jobs and workers on temporary layoff receive unemployment benefits χ_u. Then, the contemporaneous value of having a household member on temporary layoff net of having a member in search unemployment in period t is $(\chi_u + \chi_i - \chi_u) = \chi_i$.

C4. Equilibrium Recruiting Costs, Temporary-Layoff Savings, and Recall Costs

Recall that intermediate goods firms pay a fixed cost e as part of the worker recruiting process, drawn from an *i.i.d.* distribution $F(e)$, and a fixed cost ζ to recall workers on temporary layoff, drawn from an *i.i.d.* distribution $R(\zeta)$. In addition, when firms place a worker on temporary layoff, they save an amount of resources a drawn from an *i.i.d.* distribution $H(a)$. Following Leduc and Liu (2023), we adopt power distributions for $F(e) = (e/\bar{e})^{\eta_e}$, $H(a) = (a/\bar{a})^{\eta_a}$, and $R(\zeta) = \left(\zeta/\bar{\zeta}\right)^{\eta_r}$, where $\eta_a > 0$, $\eta_e > 0$, $\eta_r > 0$ and $\bar{a} > 0$, $\bar{e} > 0$, $\bar{\zeta} > 0$ are scaling parameters.

With this in mind, the total fixed costs of creating job vacancies in period t are given by $\int_0^{\widetilde{e}_t} edF(e)$. The total amount of resources saved when placing active workers on temporary layoff in period t is given by $(1-\rho_n)n_{at-1}\int_0^{\widetilde{a}_t} adH(a)$. Finally, the total cost of recalling workers on temporary layoff back to the firm in period t is given by $(1-\rho_i)n_{it-1}\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta)$. Note that

$$\begin{aligned}\int_0^{\widetilde{a}_t} adH(a) &= \int_0^{\widetilde{a}_t} ah(a)da \\ &= \int_0^{\widetilde{a}_t} \frac{a}{\bar{a}}\eta_a \left(\frac{a}{\bar{a}}\right)^{\eta_a - 1} da \\ &= \int_0^{\widetilde{a}_t} \eta_a \left(\frac{a}{\bar{a}}\right)^{\eta_a} da \\ &= \left(\frac{\eta_a}{1+\eta_a}\right)\left(\frac{\widetilde{a}_t}{\bar{a}}\right)^{\eta_a} \widetilde{a}_t \\ &= \left(\frac{\eta_a}{1+\eta_a}\right) q_{at}\widetilde{a}_t,\end{aligned}$$

where we use the fact that in equilibrium $q_{at} = H(\widetilde{a}_t) = (\widetilde{a}_t/\bar{a})^{\eta_a}$. Following identical steps shows that

$$\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) = \left(\frac{\eta_r}{1+\eta_r}\right) q_{rt}\widetilde{\zeta}_t,$$

where we use the fact that in equilibrium $q_{rt} = R(\widetilde{\zeta}_t) = \left(\widetilde{\zeta}_t/\bar{\zeta}\right)^{\eta_r}$. Finally, we can show that

$$\begin{aligned}
\int_0^{\widetilde{e}_t} edF(e) &= \int_0^{\widetilde{e}_t} ef(e)de \\
&= \int_0^{\widetilde{e}_t} \frac{e}{\bar{e}}\eta_e \left(\frac{e}{\bar{e}}\right)^{\eta_e - 1} de \\
&= \int_0^{\widetilde{e}_t} \eta_e \left(\frac{e}{\bar{e}}\right)^{\eta_e} de \\
&= \left(\frac{\eta_e}{1+\eta_e}\right)\left(\frac{\widetilde{e}_t}{\bar{e}}\right)^{\eta_e} \widetilde{e}_t \\
&= \left(\frac{\eta_e}{1+\eta_e}\right)\widetilde{e}_t v_{nt},
\end{aligned}$$

where we use the fact that in equilibrium $v_{nt} = (\widetilde{e}_t/\bar{e})^{\eta_e}$. Also, since in equilibrium $\widetilde{e}_t = \mathbf{J}_{vt}$, we can write $v_{nt} = (\widetilde{e}_t/\bar{e})^{\eta_e} = (\mathbf{J}_{vt}/\bar{e})^{\eta_e}$.

All told, it follows that the total fixed costs of vacancy creation are $\int_0^{\widetilde{e}_t} edF(e) = (\eta_e/(1+\eta_e))\mathbf{J}_{vt}v_{nt}$, the total amount of resources saved by placing active workers on temporary layoff are $(1-\rho_n)n_{at-1}\int_0^{\widetilde{a}_t} adH(a) = (1-\rho_n)n_{at-1}q_{at}(\eta_a/(1+\eta_a))\widetilde{a}_t$, and the total fixed costs associated with recalling workers on temporary layoff are $(1-\rho_i)n_{it-1}\int_0^{\widetilde{\zeta}_t}\zeta dR(\zeta) = (1-\rho_i)n_{it-1}q_{rt}(\eta_r/(1+\eta_r))\widetilde{\zeta}_t$.

C5. Benchmark Model Equilibrium Conditions

Taking the shock processes $\{Z_t, f_{E,t}\}$ as given, a symmetric private-sector equilibrium is made up of the endogenous processes $\left\{c_t, n_{at}, n_{it}, v_t, v_{nt}, \widetilde{a}_t, \widetilde{\zeta}_t, \mathbf{J}_{at}, \mathbf{J}_{it}, \mathbf{J}_{vt}\right\}$, $\left\{\mathbf{W}_{at}, \mathbf{W}_{it}, q_{at}, q_{rt}, H(\widetilde{a}_t), R(\widetilde{\zeta}_t), \widetilde{e}_t, f_t, q_t, s_t, N_t, N_{Et}, Y_t, \widetilde{y}_t, \widetilde{\rho}_t, \widetilde{d}_t, mc_t, z_{at}, \widetilde{z}_t, u_t, \mathbf{q}_t(z_{at})\right\}$ that satisfy the following equilibrium conditions

$$N_t = (1 - G(z_{at}))\left(N_{t-1} + N_{Et-1}\right), \tag{C12}$$

$$f_{Et} = E_t\left\{\Xi_{t+1|t}\left(1 - G(z_{at+1})\right)\left(\widetilde{d}_{t+1} + f_{Et+1}\right)\right\}, \tag{C13}$$

$$Y_t = N_t^{\frac{\varepsilon}{\varepsilon-1}}\widetilde{y}_t, \tag{C14}$$

$$\widetilde{\rho}_t = \frac{\varepsilon}{\varepsilon-1}\frac{mc_t}{\widetilde{z}_t}, \tag{C15}$$

$$\widetilde{d}_t = \left(\widetilde{\rho}_t - \frac{mc_t}{\widetilde{z}_t}\right)\widetilde{y}_t - f_a, \tag{C16}$$

$$\widetilde{z}_t = z_{at}\left(\frac{\kappa}{\kappa-(\varepsilon-1)}\right)^{\frac{1}{\varepsilon-1}}, \tag{C17}$$

$$\widetilde{z}_t Z_t n_{at} = N_t\widetilde{y}_t, \tag{C18}$$

(C19)
$$\mathbf{q}_t(z_{at}) = \left(\left(\frac{\varepsilon}{\varepsilon-1}\frac{mc_t}{z_{at}} - \frac{mc_t}{z_{at}}\right)\left(\frac{\varepsilon}{\varepsilon-1}\frac{mc_t}{z_{at}}\right)^{-\varepsilon} Y_t - f_a\right) + E_t\left\{\Xi_{t+1|t}\left(1 - G(z_{at+1})\right)\mathbf{q}_{t+1}(z_{at+1})\right\},$$

$$\mathbf{q}_t(z_{at}) = 0, \tag{C20}$$

$$\widetilde{\rho}_t = N_t^{\frac{1}{\varepsilon-1}}, \tag{C21}$$

$$\begin{aligned}\mathbf{W}_{at} &= (w_t - \chi_u) + (1-\rho_n)E_t\left\{\Xi_{t+1|t}\left(1 - q_{at+1} - f_{t+1}\right)\mathbf{W}_{at+1}\right\} \\ &\quad + (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\mathbf{W}_{it+1}\right\},\end{aligned} \tag{C22}$$

$$\begin{aligned}\mathbf{W}_{it} &= \chi_i + (1-\rho_i)E_t\left\{\Xi_{t+1|t}\left(q_{rt+1} - f_{t+1}\right)\mathbf{W}_{at+1}\right\} \\ &\quad + (1-\rho_i)E_t\left\{\Xi_{t+1|t}\left(1 - q_{rt+1}\right)\mathbf{W}_{it+1}\right\},\end{aligned} \tag{C23}$$

$$\begin{aligned}\mathbf{J}_{at} &= mc_t Z_t - w_t + (1-\rho_n)\,E_t\left\{\Xi_{t+1|t}(1-q_{at+1})\mathbf{J}_{at+1}\right\} \\ &\quad + (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\left(\mathbf{J}_{it+1} + \left(\frac{\eta_a}{1+\eta_a}\right)\widetilde{a}_{t+1}\right)\right\} \\ &\quad + E_t\left\{\Xi_{t+1|t}\left(\rho_n + (1-\rho_n)q_{at+1}\right)\mathbf{J}_{vt+1}\right\},\end{aligned} \tag{C24}$$

$$\begin{aligned}\mathbf{J}_{it} &= -\chi_i + (1-\rho_i)E_t\left\{\Xi_{t+1|t}(1-q_{rt+1})\mathbf{J}_{it+1}\right\} \\ &\quad + (1-\rho_i)E_t\left\{\Xi_{t+1|t}q_{rt+1}\left(\mathbf{J}_{at+1} - \left(\frac{\eta_r}{1+\eta_r}\right)\widetilde{\zeta}_{t+1}\right)\right\},\end{aligned} \tag{C25}$$

$$\mathbf{J}_{vt} = -\gamma + q_t\mathbf{J}_{at} + (1-\rho_v)(1-q_t)E_t\left\{\Xi_{t+1|t}\mathbf{J}_{vt+1}\right\}, \tag{C26}$$

(C27)

$$\begin{aligned}w_{nt} - \chi_u + (1-\rho_n)E_t\left\{\Xi_{t+1|t}\left(1 - q_{at+1} - f_{t+1}\right)\left(\frac{\eta}{1-\eta}\right)\left(\mathbf{J}_{at+1} - \mathbf{J}_{vt+1}\right)\right\} \\ + (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\mathbf{W}_{it+1}\right\} = \left(\frac{\eta}{1-\eta}\right)\left(\mathbf{J}_{at} - \mathbf{J}_{vt}\right),\end{aligned}$$

$$w_t = (w^*)^{\gamma_w}(w_{nt})^{1-\gamma_w}, \tag{C28}$$

$$\widetilde{a}_t = \mathbf{J}_{at} - \mathbf{J}_{it} - \mathbf{J}_{vt}, \tag{C29}$$

$$\widetilde{\zeta}_t = \mathbf{J}_{at} - \mathbf{J}_{it}, \tag{C30}$$

$$q_{at} = \left(\frac{\widetilde{a}_t}{\bar{a}}\right)^{\eta_a}, \tag{C31}$$

$$q_{rt} = \left(\frac{\widetilde{\zeta}_t}{\bar{\zeta}}\right)^{\eta_r}, \tag{C32}$$

$$\begin{aligned} Y_t = {} & c_t + \gamma v_t + f_{Et} N_{Et} + f_a N_t + \left(\frac{\eta_e}{1+\eta_e}\right) \mathbf{J}_{vt} v_{nt} \\ & + (1-\rho_i) n_{it-1} \left(\frac{\eta_r}{1+\eta_r}\right) q_{rt} \widetilde{\zeta}_t - (1-\rho_n) n_{at-1} \left(\frac{\eta_a}{1+\eta_a}\right) q_{at} \widetilde{a}_t, \end{aligned} \tag{C33}$$

$$n_{at} = (1-\rho_n)(1-q_{at}) n_{at-1} + q_{rt}(1-\rho_i) n_{it-1} + m(s_t, v_t), \tag{C34}$$

$$n_{it} = (1-q_{rt})(1-\rho_i) n_{it-1} + q_{at}(1-\rho_n) n_{at-1}, \tag{C35}$$

$$v_t = (1-\rho_v)(1-q_{t-1}) v_{t-1} + n_{at-1} \left(\rho_n + (1-\rho_n) q_{at}\right) + v_{nt}, \tag{C36}$$

$$\widetilde{e}_t = \mathbf{J}_{v,t}, \tag{C37}$$

$$v_{nt} = \left(\frac{\widetilde{e}_t}{\bar{e}}\right)^{\eta_e}, \tag{C38}$$

$$\theta_t = \frac{v_t}{s_t}, \tag{C39}$$

$$f_t = \frac{m(s_t, v_t)}{s_t}, \tag{C40}$$

$$q_t = \frac{m(s_t, v_t)}{v_t}, \tag{C41}$$

$$u_t = 1 - n_{at}. \tag{C42}$$

Model Mechanisms: Details

This section dissects how temporary layoffs and worker recalls from temporary layoff shape cyclical labor market, firm, and aggregate dynamics, and explores the role of real wage rigidities in determining the spillover effects from the labor market to firm entry and exit and aggregate economic activity in response to shocks.

In what follows, we explicitly derive the job creation condition and show how temporary layoffs and recalls from temporary layoff affect this condition. We also show how the measure of active employment, which is ultimately determined by job creation and hence influenced by temporary layoffs and recalls from temporary layoff, is a key factor that influences firm entry, firm exit, and ultimately output.

D1. Firm Value Equations

In this section, we rewrite the relevant firm value expressions in order to later derive the job creation condition of the model.

Recall that the value to the firm of having an active worker, $\mathbf{J}_{at}$, is given by

$$\begin{aligned}\mathbf{J}_{at} &= mc_t Z_t - w_t + (1-\rho_n)E_t\left\{\Xi_{t+1|t}\left(1-q_{at+1}\right)\mathbf{J}_{at+1}\right\}\\ &+ (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\left(\mathbf{J}_{it+1}+\left(\frac{\eta_a}{1+\eta_a}\right)\widetilde{a}_{t+1}\right)\right\}\\ &+ E_t\left\{\Xi_{t+1|t}\left(\rho_n+(1-\rho_n)q_{at+1}\right)\mathbf{J}_{vt+1}\right\},\end{aligned}$$

where we use the fact that $\int_0^{\widetilde{a}_{t+1}} adH(a) = \left(\eta_a/\left(1+\eta_a\right)\right)q_{at+1}\widetilde{a}_{t+1}$. Recalling that in equilibrium $\widetilde{a}_t = \mathbf{J}_{at} - \mathbf{J}_{it} - \mathbf{J}_{vt}$ and $\widetilde{\zeta}_t = \mathbf{J}_{at} - \mathbf{J}_{it}$, it follows that $\mathbf{J}_{vt} = \widetilde{\zeta}_t - \widetilde{a}_t$. Therefore, we can write $\mathbf{J}_{at}$ as

$$\begin{aligned}\mathbf{J}_{at} &= mc_t Z_t - w_t + (1-\rho_n)E_t\left\{\Xi_{t+1|t}\left(1-q_{at+1}\right)\mathbf{J}_{at+1}\right\}\\ &+ (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\left(\mathbf{J}_{it+1}+\left(\frac{\eta_a}{1+\eta_a}\right)\widetilde{a}_{t+1}\right)\right\}\\ &+ E_t\left\{\Xi_{t+1|t}\left(\rho_n+(1-\rho_n)q_{at+1}\right)\left(\widetilde{\zeta}_{t+1}-\widetilde{a}_{t+1}\right)\right\}.\end{aligned}$$

Breaking down this expression further, we have

$$\begin{aligned}\mathbf{J}_{at} &= mc_t Z_t - w_t + (1-\rho_n)E_t\left\{\Xi_{t+1|t}\mathbf{J}_{at+1}\right\} - (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\left(\mathbf{J}_{at+1}-\mathbf{J}_{it+1}\right)\right\}\\ &+ (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\left(\left(\frac{\eta_a}{1+\eta_a}\right)\widetilde{a}_{t+1}\right)\right\}\\ &+ E_t\left\{\Xi_{t+1|t}\left(\rho_n+(1-\rho_n)q_{at+1}\right)\left(\widetilde{\zeta}_{t+1}-\widetilde{a}_{t+1}\right)\right\},\end{aligned}$$

or, using $\widetilde{\zeta}_t = \mathbf{J}_{at} - \mathbf{J}_{it}$ once again,

$$\begin{aligned}\mathbf{J}_{at} &= mc_t Z_t - w_t + (1-\rho_n)E_t\left\{\Xi_{t+1|t}\mathbf{J}_{at+1}\right\} - (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\widetilde{\zeta}_{t+1}\right\}\\ &+ (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\left(\left(\frac{\eta_a}{1+\eta_a}\right)\widetilde{a}_{t+1}\right)\right\}\\ &+ E_t\left\{\Xi_{t+1|t}\left(\rho_n + (1-\rho_n)q_{at+1}\right)\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\},\end{aligned}$$

which can be written as

$$\begin{aligned}\mathbf{J}_{at} &= mc_t Z_t - w_t + (1-\rho_n)E_t\left\{\Xi_{t+1|t}\mathbf{J}_{at+1}\right\}\\ &+ (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\left(\left(\frac{\eta_a}{1+\eta_a}\right)\widetilde{a}_{t+1} - \widetilde{\zeta}_{t+1}\right)\right\}\\ &+ E_t\left\{\Xi_{t+1|t}\left(\rho_n + (1-\rho_n)q_{at+1}\right)\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\}.\end{aligned}$$

Turning to the value of a vacancy, $\mathbf{J}_{vt}$, we have

$$\mathbf{J}_{vt} = -\gamma + q_t\mathbf{J}_{at} + (1-\rho_v)(1-q_t)E_t\left\{\Xi_{t+1|t}\mathbf{J}_{vt+1}\right\},$$

which we can write as

$$\mathbf{J}_{at} = \frac{1}{q_t}\left(\gamma + \mathbf{J}_{vt} - (1-\rho_v)(1-q_t)E_t\left\{\Xi_{t+1|t}\mathbf{J}_{vt+1}\right\}\right),$$

or, using the equilibrium condition $\mathbf{J}_{vt} = \left(\widetilde{\zeta}_t - \widetilde{a}_t\right)$,

$$\text{(D1)}\qquad \mathbf{J}_{at} = \frac{1}{q_t}\left(\gamma + \left(\widetilde{\zeta}_t - \widetilde{a}_t\right) - (1-\rho_v)(1-q_t)E_t\left\{\Xi_{t+1|t}\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\}\right).$$

D2. Job Creation Condition

Derivation of Job Creation Condition. — To derive an explicit expression of the job creation condition, consider the firm value expressions

$$\begin{aligned}\mathbf{J}_{at} &= mc_t Z_t - w_t + (1-\rho_n)E_t\left\{\Xi_{t+1|t}\mathbf{J}_{at+1}\right\}\\ &+ (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\left(\left(\frac{\eta_a}{1+\eta_a}\right)\widetilde{a}_{t+1} - \widetilde{\zeta}_{t+1}\right)\right\}\\ &+ E_t\left\{\Xi_{t+1|t}\left(\rho_n + (1-\rho_n)q_{at+1}\right)\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\}.\end{aligned}$$

and

$$\mathbf{J}_{at} = \frac{1}{q_t}\left(\gamma + \left(\widetilde{\zeta}_t - \widetilde{a}_t\right) - (1-\rho_v)(1-q_t)E_t\left\{\Xi_{t+1|t}\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\}\right),$$

from Section D.D1, where we use the fact that in equilibrium $\mathbf{J}_{vt} = \left(\widetilde{\zeta}_t - \widetilde{a}_t\right)$. We can write the initial expression for $\mathbf{J}_{at}$ as

$$\begin{aligned}
0 &= mc_t Z_t - w_t \\
&- \frac{1}{q_t}\left(\gamma + \left(\widetilde{\zeta}_t - \widetilde{a}_t\right) - (1-\rho_v)(1-q_t)E_t\left\{\Xi_{t+1|t}\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\}\right) \\
&+ (1-\rho_n)E_t\left\{\Xi_{t+1|t}\frac{1}{q_{t+1}}\left(\gamma + \left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right) - (1-\rho_v)(1-q_{t+1})E_t\left\{\Xi_{t+2|t+1}\left(\widetilde{\zeta}_{t+2} - \widetilde{a}_{t+2}\right)\right\}\right)\right\} \\
&+ E_t\left\{\Xi_{t+1|t}\left(\rho_n + (1-\rho_n)q_{at+1}\right)\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\} \\
&+ (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\left(\left(\frac{\eta_a}{1+\eta_a}\right)\widetilde{a}_{t+1} - \widetilde{\zeta}_{t+1}\right)\right\}.
\end{aligned}$$

Then, rearranging the terms in this last expression, we obtain

$$\begin{aligned}
\frac{\gamma}{q_t} &= mc_t Z_t - w_t + (1-\rho_n)E_t\left\{\Xi_{t+1|t}\frac{\gamma}{q_{t+1}}\right\} \\
&- \left(\frac{\left(\widetilde{\zeta}_t - \widetilde{a}_t\right)}{q_t} - (1-\rho_n)E_t\left\{\Xi_{t+1|t}\frac{\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)}{q_{t+1}}\right\}\right) \\
&+ \left(\frac{(1-\rho_v)(1-q_t)}{q_t}\right)E_t\left\{\Xi_{t+1|t}\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\} \\
&+ E_t\left\{\Xi_{t+1|t}\left(\rho_n + (1-\rho_n)q_{at+1}\right)\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\} \\
&- (1-\rho_n)E_t\left\{\Xi_{t+1|t}\left(\frac{(1-\rho_v)(1-q_{t+1})}{q_{t+1}}\right)E_t\left\{\Xi_{t+2|t+1}\left(\widetilde{\zeta}_{t+2} - \widetilde{a}_{t+2}\right)\right\}\right\} \\
&+ (1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\left(\left(\frac{\eta_a}{1+\eta_a}\right)\widetilde{a}_{t+1} - \widetilde{\zeta}_{t+1}\right)\right\}.
\end{aligned} \tag{D2}$$

where the first line, *on its own*, represents the job creation condition in the standard search and matching model. Indeed, in the absence of temporary layoffs, $q_{at} = 0$ and $q_{rt} = 0$ for all t, and expression (D2) collapses to $\gamma/q_t = mc_t Z_t - w_t + (1-\rho_n)E_t\left\{\Xi_{t+1|t}\gamma/q_{t+1}\right\}$. The second, third, fourth, and fifth lines of expression (D2) therefore capture the influence of temporary layoffs and recalls from temporary layoff on optimal job creation.

Rearranging terms, we can rewrite expression (D2) as

$$
\begin{aligned}
\frac{\gamma}{q_t} =& mc_t Z_t - w_t + (1-\rho_n) E_t \left\{ \Xi_{t+1|t} \frac{\gamma}{q_{t+1}} \right\} \\
& - \frac{\left(\widetilde{\zeta}_t - \widetilde{a}_t\right) - (1-\rho_v)(1-q_t) E_t \left\{ \Xi_{t+1|t} \left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\}}{q_t} \\
& + E_t \left\{ \Xi_{t+1|t} (1-\rho_n) \left(\frac{\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)}{q_{t+1}} \right) \right\} \\
& - E_t \left\{ \Xi_{t+1|t} (1-\rho_n) \left(\frac{(1-\rho_v)(1-q_{t+1}) E_{t+1} \left\{ \Xi_{t+2|t+1} \left(\widetilde{\zeta}_{t+2} - \widetilde{a}_{t+2}\right)\right\}}{q_{t+1}} \right) \right\} \\
& + E_t \left\{ \Xi_{t+1|t} \left(\rho_n + (1-\rho_n) q_{at+1}\right) \left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right) \right\} \\
& + (1-\rho_n) E_t \{ \Xi_{t+1|t} (\underbrace{\left(\eta_a / \left(1+\eta_a\right)\right) q_{at+1} \widetilde{a}_{t+1}}_{\int_0^{\widetilde{a}_{t+1}} a dH(a)} - q_{at+1} \widetilde{\zeta}_{t+1}) \}.
\end{aligned} \tag{D3}
$$

In general terms, the left-hand-side of equation (D3) represents the expected marginal cost of posting a vacancy while the right-hand-side represents the expected marginal benefit of posting a vacancy.

Summary of Job Creation Condition. — Based on the derivations in Section D.D2, we can rewrite expression (D3) more compactly as

$$
\frac{\gamma}{q_t} = mc_t Z_t - (w_t - \Psi_{ar,t}) + (1-\rho_n) E_t \left\{ \Xi_{t+1|t} \frac{\gamma}{q_{t+1}} \right\},
$$

where recall that the real wage is $w_t = (w^*)^{\gamma_w}(w_{nt})^{1-\gamma_w}$, $0 \leq \gamma_w \leq 1$ dictates the degree of real wage rigidity, and w_{nt} is the Nash real wage. We define the term

$$\Psi_{ar,t} \equiv -\left\{ \frac{\left(\widetilde{\zeta}_t - \widetilde{a}_t\right) - (1-\rho_v)(1-q_t)E_t\left\{\Xi_{t+1|t}\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\}}{q_t} \right\}$$

$$+ E_t\left\{\Xi_{t+1|t}(1-\rho_n)\left(\frac{\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)}{q_{t+1}}\right)\right\}$$

$$- E_t\left\{\Xi_{t+1|t}(1-\rho_n)\left(\frac{(1-\rho_v)(1-q_{t+1})E_{t+1}\left\{\Xi_{t+2|t+1}\left(\widetilde{\zeta}_{t+2} - \widetilde{a}_{t+2}\right)\right\}}{q_{t+1}}\right)\right\}$$

$$+ E_t\left\{\Xi_{t+1|t}\left(\rho_n\widetilde{\zeta}_{t+1} - (\rho_n + (1-\rho_n)q_{at+1})\,\widetilde{a}_{t+1} + (1-\rho_n)\left(\int_0^{\widetilde{a}_{t+1}} adH(a)\right)\right)\right\}.$$

Broadly speaking, the term $\Psi_{ar,t}$ embodies the separate influence of temporary layoffs and recalls from temporary layoff on firms' job creation decisions *for a given real wage.*

To understand the term $\Psi_{ar,t}$, first focus on the first line of $\Psi_{ar,t}$. Recall that placing a worker on temporary layoff allows firms to save resources $\widetilde{a}_t = \bar{a}\,(q_{at})^{\frac{1}{\eta_a}}$ with $\eta_a > 0$, while bringing workers back from temporary layoff entails an expenditure by the firm, $\widetilde{\zeta}_t = \bar{\zeta}\,(q_{rt})^{\frac{1}{\eta_r}}$ with $\eta_r > 0$. Thus, $\left(\widetilde{\zeta}_t - \widetilde{a}_t\right) \geq 0$ can be interpreted as the *net* cost of bringing a worker who is currently on temporary layoff back to the firm in period t—that is, the cost of recalling a worker on temporary layoff net of the resources that the firm saves when it places a worker on temporary layoff. Next, with probability $(1-\rho_v)$, a vacancy posted in the previous period remains active and with probability $(1-q_t)$ the vacancy is unsuccessfully filled by a new match. This increases the value of being able to recall a worker from temporary layoff to fill that vacancy. Hence the term $(1-\rho_v)(1-q_t)E_t\left\{\Xi_{t+1|t}\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\}$ in the first line of $\Psi_{ar,t}$. All told, the first line of $\Psi_{ar,t}$ can be interpreted as the net cost of job creation stemming from recalling a worker from temporary layoff, where this net cost is a component of the overall cost of bringing a worker back to the firm to produce.

The term $E_t\left\{\Xi_{t+1|t}\left(\rho_n + (1-\rho_n)q_{at+1}\right)\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\}$ in $\Psi_{ar,t}$ captures the fact that with probability $0 < \rho_n < 1$ a worker separates from the firm next period and with probability $0 < (1-\rho_n)q_{at+1} < 1$ a worker remains at the firm but is placed on temporary layoff next period. Under both scenarios, a firm can recall a worker from temporary layoff to fill the vacancy, a choice that has a net value of $\left(\widetilde{\zeta} - \widetilde{a}\right)$. Finally, the term $(1-\rho_n)E_t\left\{\Xi_{t+1|t}q_{at+1}\left(\left(\eta_a/\left(1+\eta_a\right)\right)\widetilde{a}_{t+1} - \widetilde{\zeta}_{t+1}\right)\right\}$ in $\Psi_{ar,t}$ captures the fact that with probability $(1-\rho_n)$, a worker remains employed at the firm next period but with probability q_{at+1} that worker is placed on temporary layoff next period, in which case the firm saves an average amount of resources $\int_0^{\widetilde{a}_{t+1}} adH(a) = (\eta_a/(1+\eta_a))\, q_{at+1}\widetilde{a}_{t+1}$ net of the threshold amount of resources that the firm would need to spend to bring a worker on temporary layoff back to the firm. Since we know that $\left(\widetilde{\zeta}_t - \widetilde{a}_t\right) \geq 0$ for all t, then it follows that $\left((\eta_a/(1+\eta_a))\,\widetilde{a}_{t+1} - \widetilde{\zeta}_{t+1}\right) < 0$ and therefore $(1-\rho_n)E_t\{\Xi_{t+1|t}q_{at+1}((\eta_a/(1+\eta_a))\,\widetilde{a}_{t+1} - \widetilde{\zeta}_{t+1})\} < 0$.

Note that the term $\Psi_{ar,t}$ can be expressed more compactly as

$$\Psi_{ar,t} \equiv -\frac{\left(\widetilde{\zeta}_t - \widetilde{a}_t\right) - (1-\rho_v)(1-q_t)E_t\left\{\Xi_{t+1|t}\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right)\right\}}{q_t}$$
$$+ E_t\left\{\Xi_{t+1|t}(1-\rho_n)\left(\frac{\left(\widetilde{\zeta}_{t+1} - \widetilde{a}_{t+1}\right) - (1-\rho_v)(1-q_{t+1})E_{t+1}\left\{\Xi_{t+2|t+1}\left(\widetilde{\zeta}_{t+2} - \widetilde{a}_{t+2}\right)\right\}}{q_{t+1}}\right)\right\}$$
$$+ E_t\left\{\Xi_{t+1|t}\left(\rho_n\widetilde{\zeta}_{t+1} - (\rho_n + (1-\rho_n)q_{at+1})\,\widetilde{a}_{t+1} + (1-\rho_n)\left(\frac{\eta_a}{1+\eta_a}\right)\widetilde{a}_{t+1}q_{at+1}\right)\right\},$$

which is the expression for $\Psi_{ar,t}$ used in the main text, where we used the fact that $\int_0^{\widetilde{a}_{t+1}} adH(a) = \left(\frac{\eta_a}{1+\eta_a}\right)\widetilde{a}_{t+1}q_{at+1}$.

D3. *Temporary Layoffs and Firm-Entry Dynamics*

Temporary Layoffs and Marginal Cost. — Using the job creation condition, we can express the real marginal cost of final-goods firms as follows:

$$mc_t = \frac{1}{Z_t}\left((w_t - \Psi_{ar,t}) + \frac{\gamma}{q_t} - (1-\rho_n)E_t\left\{\Xi_{t+1|t}\frac{\gamma}{q_{t+1}}\right\}\right),$$

where the term $\Psi_{ar,t}$ is a function of $\widetilde{a}$ and $\widetilde{\zeta}$ and therefore embodies the choices over temporary layoffs and recalls from temporary layoff. Defining $\boldsymbol{A}_t \equiv (w_t - \Psi_{ar,t})$ as the component of the marginal cost associated with having an active worker and $\boldsymbol{Q}_t \equiv \gamma/q_t - (1-\rho_n)E_t\left\{\Xi_{t+1|t}\gamma/q_{t+1}\right\}$ as the component of the marginal cost associated with vacancy creation, we can write the real marginal cost as

$$mc_t = \frac{\boldsymbol{A}_t + \boldsymbol{Q}_t}{Z_t}.$$

Firm Profits, Temporary Layoffs, and Firm Creation Decisions. — Using the expression for average final-goods individual-firm profits

$$\widetilde{d}_t = \left(\widetilde{\rho}_t - \frac{mc_t}{\widetilde{z}_t}\right)\widetilde{y}_t - f_a,$$

the average firm's demand function $\widetilde{y}_t = (\widetilde{\rho}_t)^{-\varepsilon} Y_t$, and the optimal pricing condition $\widetilde{\rho}_t = (\varepsilon/(\varepsilon-1))\, mc_t/\widetilde{z}_t$, we can write

$$\widetilde{d}_t = \left(\frac{1}{\varepsilon}\right)\left(\frac{\varepsilon}{\varepsilon-1}\frac{mc_t}{\widetilde{z}_t}\right)^{1-\varepsilon} Y_t - f_a.$$

Using the fact that $\widetilde{z}_t = z_{at}\left(\kappa/\left(\kappa-(\varepsilon-1)\right)\right)^{\frac{1}{\varepsilon-1}}$ and the expression for the marginal cost above, $mc_t = \left(\boldsymbol{A}_t + \boldsymbol{Q}_t\right)/Z_t$, we can write average firm profits as:

$$\widetilde{d}_t = \varpi\left(\frac{\boldsymbol{A}_t + \boldsymbol{Q}_t}{Z_t z_{at}}\right)^{1-\varepsilon} Y_t - f_a,$$

where $\varpi \equiv \left(\kappa/\left(\kappa-(\varepsilon-1)\right)\right)\left(1/(\varepsilon-1)\right)\left((\varepsilon-1)/\varepsilon\right)^{\varepsilon}$. Then, it is straightforward to show that $\partial\widetilde{d}_t/\partial\boldsymbol{A}_t < 0$. Finally, turning to optimal firm creation condition,

$$f_{Et} = E_t\left\{\Xi_{t+1|t}\left(1-G(z_{at+1})\right)\left(\widetilde{d}_{t+1} + f_{Et+1}\right)\right\},$$

it follows that an increase in $\boldsymbol{A}$ will reduce average-firm real profits, the expected marginal benefit of creating a new firm, and therefore the incentive to create a new firm.

TEMPORARY LAYOFFS AND FIRM EXIT DECISIONS. — Turning to the condition that pins down firm exit, by using the fact that $\mathbf{q}_t(z_{at}) = 0$ implicitly pins down z_{at} for all t, the expression

$$\mathbf{q}_t(z_{at}) = \left(\left(\frac{\varepsilon}{\varepsilon-1}\frac{mc_t}{z_{at}} - \frac{mc_t}{z_{at}}\right)\left(\frac{\varepsilon}{\varepsilon-1}\frac{mc_t}{z_{at}}\right)^{-\varepsilon} Y_t - f_a\right) + E_t\left\{\Xi_{t+1|t}\left(1-G(z_{at+1})\right)\mathbf{q}_{t+1}(z_{at+1})\right\},$$

collapses to

$$f_a = \left(\frac{1}{\varepsilon}\right)\left(\frac{\varepsilon}{\varepsilon-1}\frac{mc_t}{z_{at}}\right)^{1-\varepsilon} Y_t.$$

which implicitly pins down the endogenous productivity threshold z_{at} below which the firm exits. Using the expression for the marginal cost $mc_t = \left(\boldsymbol{A}_t + \boldsymbol{Q}_t\right)/Z_t$,we can write the optimal firm exit condition as

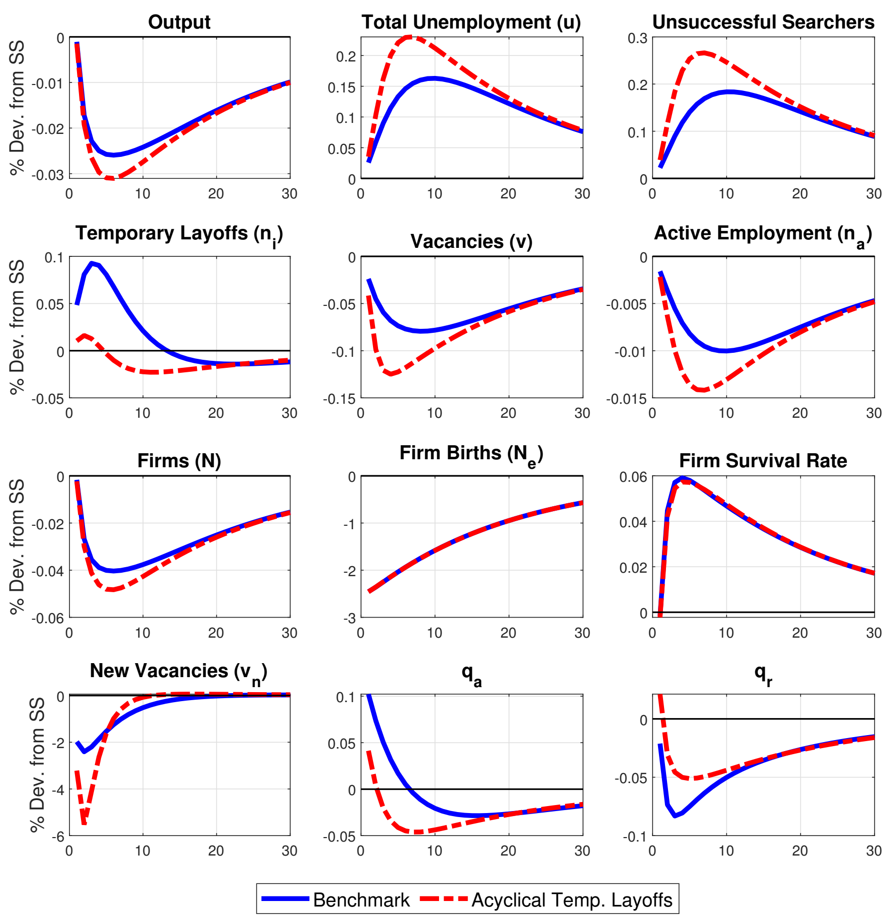
$$f_a = \left(\frac{1}{\varepsilon}\right)\left(\frac{\varepsilon}{\varepsilon-1}\frac{\boldsymbol{A}_t + \boldsymbol{Q}_t}{z_{at} Z_t}\right)^{1-\varepsilon} Y_t.$$

Then, it is easy to show that $\partial z_{at}/\partial \boldsymbol{A}_t > 0$.

Additional Model Results

E1. Impulse Responses to Adverse Firm-Creation Cost Shock in Benchmark Model

Figure E1. Impulse Response Functions to One-Standard-Deviation Adverse Firm-Creation Cost (f_{Et}) Shock in Benchmark Model and Model with Acyclical Temporary Layoffs



Note: The x axis denotes quarters after the shock. Unemployed searchers in period t are given by $(1-f_t)s_t$ while total unemployment includes temporary layoffs n_{it} and is given by $u_t = (1-f_t)s_t + n_{it} = 1 - n_{at}$. Firm births and the firm survival rate in period t are given by N_{Et} and $(1 - G(z_{at}))$, respectively.

E2. Benchmark Model with Fully Flexible Wages

Table E1 compares the results in Table 4 in the main text to those in a version of the benchmark model with flexible real wages. Figure E2 compares the lag-lead structure generated by the benchmark model and the model with flexible wages to the data.

Table E1—Cyclical Firm and Labor Market Dynamics: Data vs. Benchmark Model and Model with Flexible Real Wages

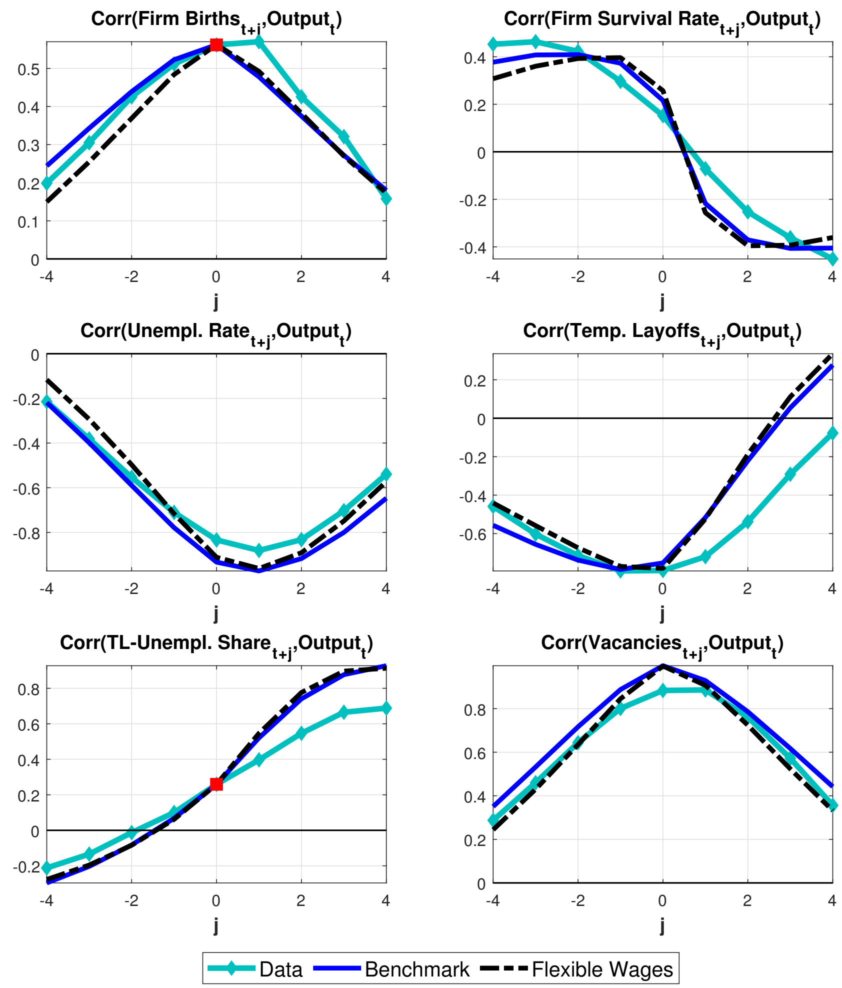
	Relative Standard Deviation						
	Firm Births	Firm Surv. Rate	Unempl. Rate	Temp. Layoffs (TL)	TL–Unempl. Share	Vacancies	Market Tightness
Data	**3.37**	**0.13**	**11.34**	**9.20**	**6.60**	**11.87**	**23.26**
Benchmark	**2.80**	**0.70**	**6.77**	**5.66**	**6.45**	**3.56**	**10.22**
Flex. Wages	**2.75**	**0.81**	**2.63**	**2.12**	**2.47**	**1.42**	**4.00**

	Contemporaneous Correlation with Output						
	Firm Births	Firm Surv. Rate	Unempl. Rate	Temp. Layoffs (TL)	TL–Unempl. Share	Vacancies	Market Tightness
Data	**0.561**	**0.152**	**–0.834**	**–0.792**	**0.259**	**0.883**	**0.899**
Benchmark	**0.561***	**0.222**	**–0.904**	**–0.786**	**0.259***	**0.989**	**0.943**
Flex. Wages	**0.563***	**0.258**	**–0.889**	**–0.801**	**0.259***	**0.989**	**0.935**

	First-Order Autocorrelation						
	Firm Births	Firm Surv. Rate	Unempl. Rate	Temp. Layoffs (TL)	TL–Unempl. Share	Vacancies	Market Tightness
Data	**0.381**	**0.489**	**0.943**	**0.769**	**0.654**	**0.914**	**0.934**
Benchmark	**0.761**	**0.328**	**0.954**	**0.883**	**0.947**	**0.922**	**0.946**
Flex. Wages	**0.762**	**0.268**	**0.944**	**0.859**	**0.940**	**0.900**	**0.932**

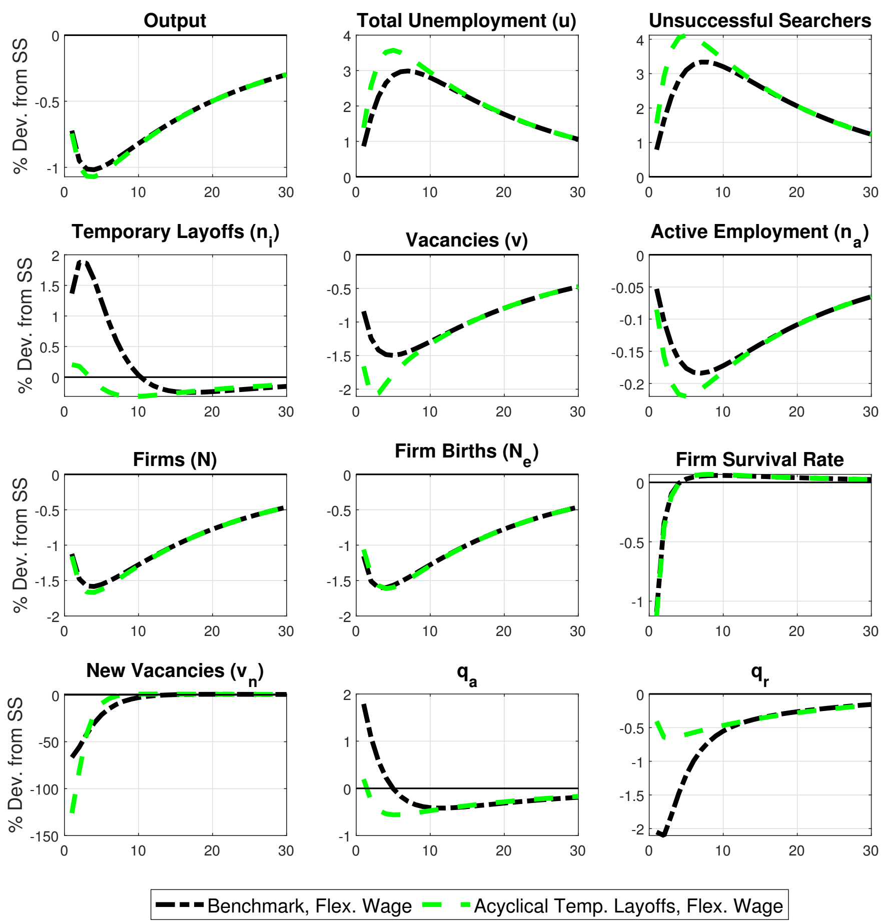
Note: The relative standard deviation is the standard deviation of a variable relative to the standard deviation of real GDP. The firm survival rate (Firm Surv. Rate) is computed as 1 minus the firm death rate using data from the BLS Business Employment Dynamics database. Unempl. Rate is the civilian unemployment rate, Temp. Layoffs (TL) is the number of individuals on temporary layoff, and the TL-Unempl. Share is the share of temporary layoffs in total unemployment. The data in this table spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics) except for vacancies and market tightness, which span 2001Q1-2019Q3 due to the time series on vacancies. See Appendix B.B1 for variable definitions sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (when appropriate) and a Hodrick-Prescott (HP) filter with smoothing parameter 1600. To compare the model to the data, in the benchmark model in period t, firm births are given by N_{Et} while the firm survival rate is $(1 - G(z_{at}))$. The model counterpart of market tightness in the data is $\Theta_t = v_t/u_t$. A * denotes a targeted second moment.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

FIGURE E2. CYCLICAL FIRM AND LABOR MARKET DYNAMICS: LEADS AND LAGS WITH OUTPUT, DATA VS. BENCHMARK MODEL AND MODEL WITH FLEXIBLE WAGES



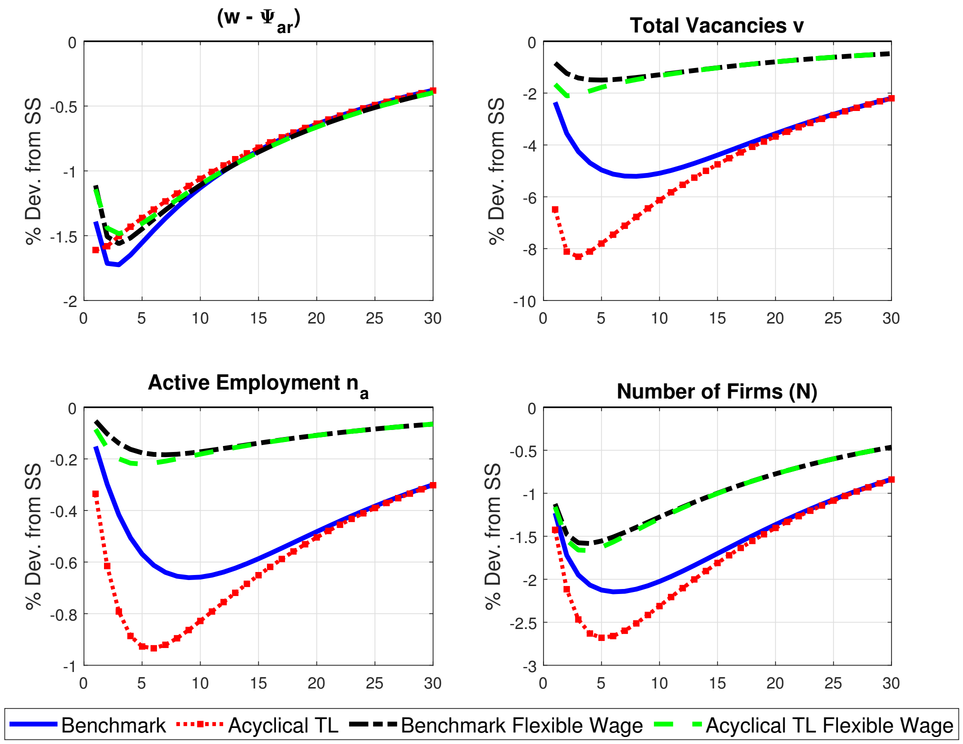
Note: The firm survival rate (Firm Surv. Rate) is computed as 1 minus the firm death rate using data from the BLS Business Employment Dynamics database. Unempl. Rate is the civilian unemployment rate, Temp. Layoffs (TL) is the number of individuals on temporary layoff, and the TL-Unempl. Share is the share of temporary layoffs in total unemployment. The data in this table spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics) except for vacancies and market tightness, which span 2001Q1-2019Q3 due to the time series on vacancies. See Appendix B.B1 for variable definitions, sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (when appropriate) and a Hodrick-Prescott (HP) filter with smoothing parameter 1600. To compare the model to the data, in the benchmark model in period t, firm births in are given by N_{Et} while the firm survival rate is $(1 - G(z_{at}))$. The red square marks a targeted second moment.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

FIGURE E3. IMPULSE RESPONSE FUNCTIONS TO A ONE-STANDARD-DEVIATION ADVERSE AGGREGATE PRODUCTIVITY (Z_t) SHOCK IN BENCHMARK MODEL VS. ACYCLICAL TEMPORARY LAYOFFS, MODELS WITH FLEXIBLE WAGES



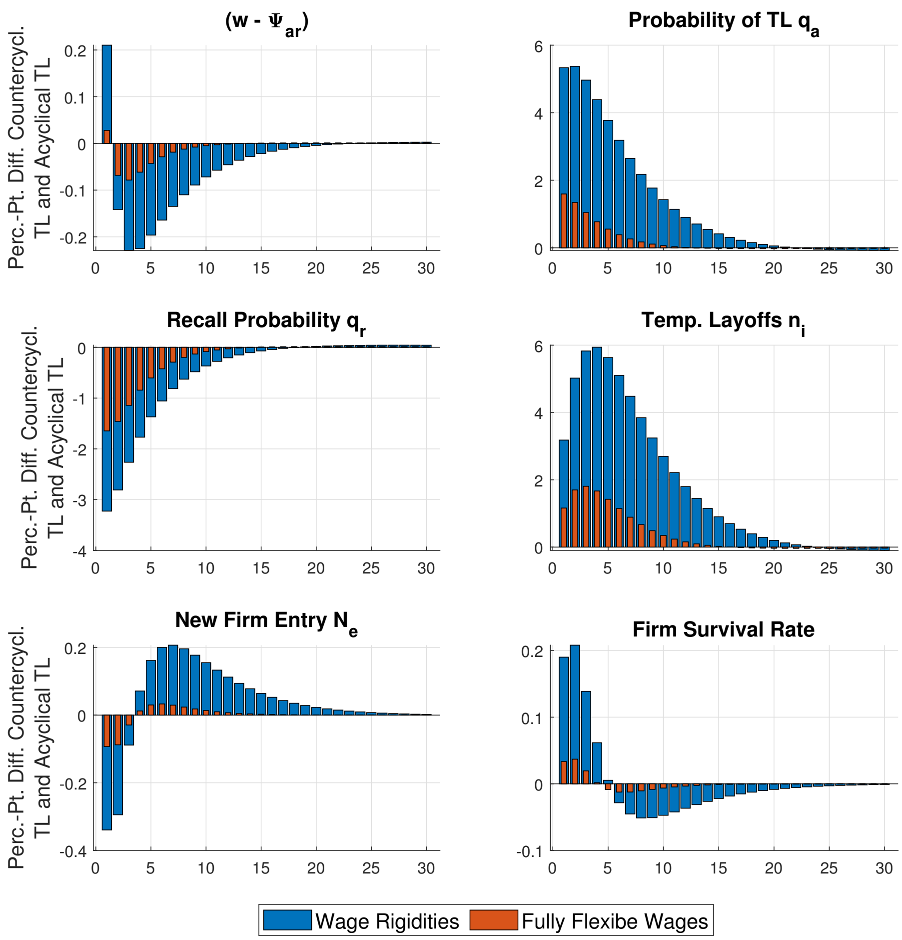
Note: The x axis denotes quarters after the shock. Unemployed searchers in period t are given by $(1-f_t)s_t$ while total unemployment includes temporary layoffs n_{it} and is given by $u_t = (1-f_t)s_t + n_{it} = 1 - n_{at}$. Firm births and the firm survival rate in period t are given by N_{Et} and $(1 - G(z_{at}))$, respectively.

FIGURE E4. RESPONSE OF $(w_t - \Psi_{ar,t})$, v_t, n_{at}, AND N_t TO ONE-STANDARD-DEVIATION ADVERSE AGGREGATE PRODUCTIVITY (Z_t) SHOCK—BENCHMARK MODEL VS. VERSION WITH FLEXIBLE REAL WAGES, COUNTERCYCLICAL VS. ACYCLICAL TEMPORARY LAYOFFS



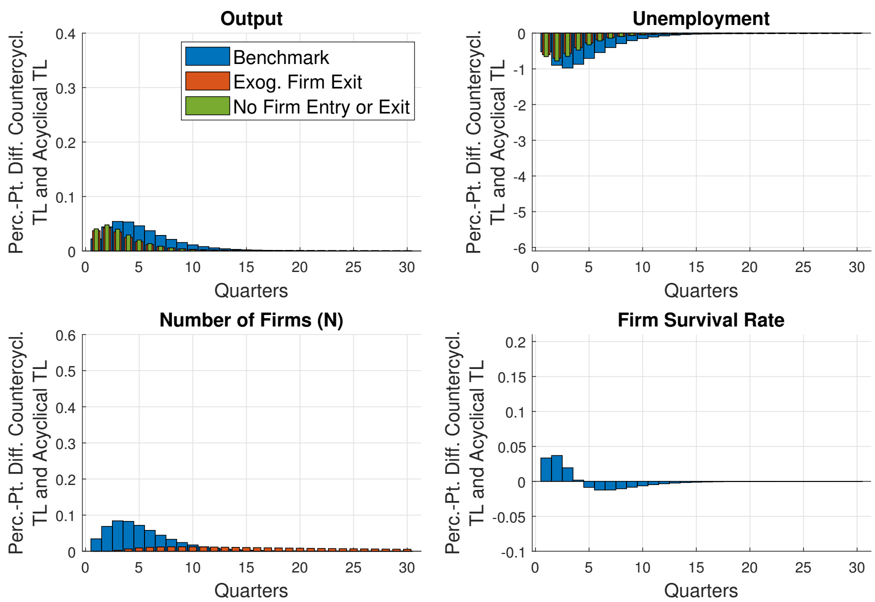
Note: The x axis denotes quarters after the shock. TL denotes temporary layoffs.

FIGURE E5. DIFFERENCES IN IMPULSE RESPONSES TO ONE-STANDARD-DEVIATION ADVERSE AGGREGATE PRODUCTIVITY (Z_t) SHOCK BETWEEN BENCHMARK MODEL WITH COUNTERCYCLICAL TEMPORARY LAYOFFS AND BENCHMARK MODEL WITH ACYCLICAL TEMPORARY LAYOFFS—WAGE RIGIDITIES VS. FLEXIBLE WAGES, ADDITIONAL VARIABLES



Note: The x axis denotes quarters after the shock. TL denotes temporary layoffs. Each subfigure plots the difference between the impulse response function of relevant variables in the model with countercyclical temporary layoffs and in the same model under acyclical temporary layoffs, for both rigid-wage (blue) and flexible-wage (orange) versions of the model.

Figure E6. Differences in Impulse Responses to One-Standard-Deviation Adverse Aggregate Productivity (Z_t) Shock Between Model with Countercyclical Temporary Layoffs and Model with Acyclical Temporary Layoffs—Output, Unemployment, Firms, and Firm Survival in Benchmark Model vs. Exogenous Firm Exit vs. No Firm Entry or Exit, All Models with Flexible Wages



Note: The x axis denotes quarters after the shock and the y axis shows the percentage-point difference (Perc.-Pt. Diff.) between the impulse response of a variable under countercyclical temporary layoffs and the impulse response of the same variable under acyclical temporary layoffs, where TL denotes temporary layoffs. The model with exogenous firm exit assumes that the firm survival rate $(1 - G(z_{at})) = (1 - \delta)$ where $0 < \delta < 1$ is a parameter chosen to match the average firm survival rate in the data. The model without firm entry or exit has the same steady state as the benchmark model but N, N_E, and z_a remain fixed at their steady state values. The blue bars show the above-mentioned percentage-point differences between impulse responses in the benchmark model, the orange bars show the above-mentioned percentage-point differences between impulse responses in the model with exogenous firm exit, and the green bars show the above-mentioned percentage-point differences between impulse responses in the model with no firm entry or exit.

E3. Model with Endogenous Job Search During Temporary Layoff

Table E2 shows a version of Table 4 in the main text where we assume that workers on temporary layoff endogenously search for new jobs (we assume convex (or more specifically, quadratic) job search costs during temporary layoff). Figure E7 compares the lag-lead structure in the benchmark model and in the model with endogenous job search during temporary layoff to the data.

Table E2—Cyclical Firm and Labor Market Dynamics: Data vs. Benchmark Model and Model with Endogenous Job Search During Temporary Layoff

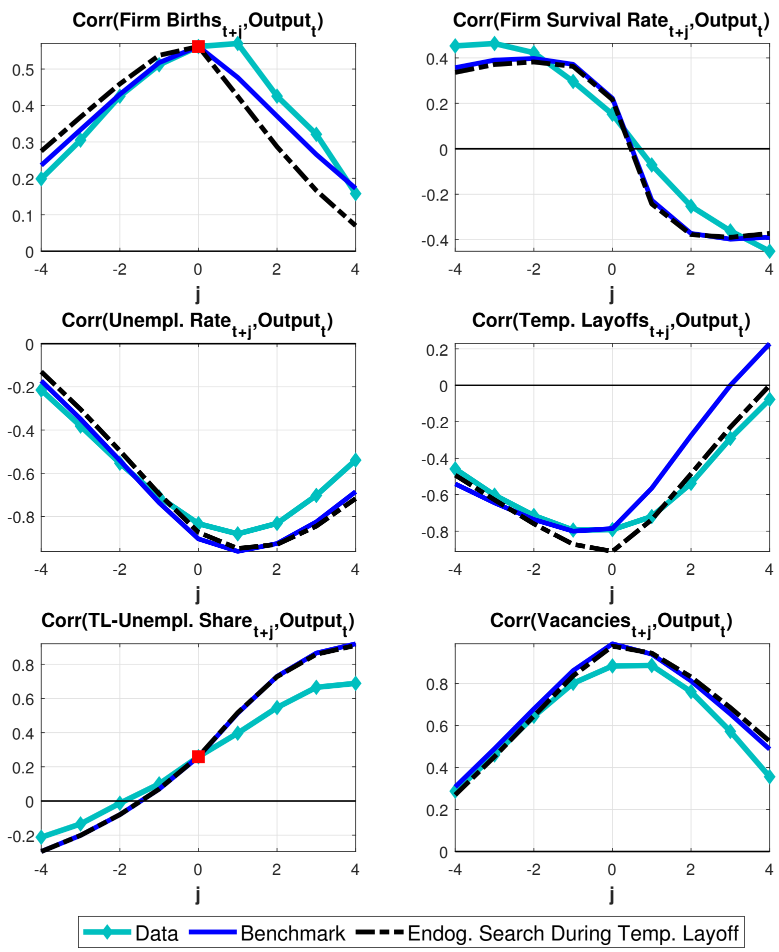
	Relative Standard Deviation						
	Firm Births	Firm Surv. Rate	Unempl. Rate	Temp. Layoffs (TL)	TL–Unempl. Share	Vacancies	Market Tightness
Data	**3.37**	**0.13**	**11.34**	**9.20**	**6.60**	**11.87**	**23.26**
Benchmark	**2.80**	**0.70**	**6.77**	**5.66**	**6.45**	**3.56**	**10.22**
TL Search	**3.23**	**0.72**	**6.15**	**4.52**	**4.85**	**3.20**	**9.25**

	Contemporaneous Correlation with Output						
	Firm Births	Firm Surv. Rate	Unempl. Rate	Temp. Layoffs (TL)	TL–Unempl. Share	Vacancies	Market Tightness
Data	**0.561**	**0.152**	**–0.834**	**–0.792**	**0.259**	**0.883**	**0.899**
Benchmark	**0.561***	**0.222**	**–0.904**	**–0.786**	**0.259***	**0.989**	**0.943**
TL Search	**0.562***	**0.216**	**–0.874**	**–0.911**	**0.260***	**0.978**	**0.919**

	First-Order Autocorrelation						
	Firm Births	Firm Surv. Rate	Unempl. Rate	Temp. Layoffs (TL)	TL–Unempl. Share	Vacancies	Market Tightness
Data	**0.381**	**0.489**	**0.943**	**0.769**	**0.654**	**0.914**	**0.934**
Benchmark	**0.761**	**0.328**	**0.954**	**0.883**	**0.947**	**0.922**	**0.946**
TL Search	**0.743**	**0.300**	**0.957**	**0.889**	**0.948**	**0.926**	**0.949**

Note: The relative standard deviation is the standard deviation of a variable relative to the standard deviation of real GDP. The firm survival rate (Firm Surv. Rate) is computed as 1 minus the firm death rate using data from the BLS Business Employment Dynamics database. Unempl. Rate is the civilian unemployment rate, Temp. Layoffs (TL) is the number of individuals on temporary layoff, and the TL-Unempl. Share is the share of temporary layoffs in total unemployment. The data in this table spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics) except for vacancies and market tightness, which span 2001Q1-2019Q3 due to the time series on vacancies. See Appendix B.B1 for variable definitions, sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (when appropriate) and a Hodrick-Prescott (HP) filter with smoothing parameter 1600. To compare the model to the data, in the benchmark model in period t, firm births are given by N_{Et} while the firm survival rate is $(1 - G(z_{at}))$. The model counterpart of market tightness in the data is $\Theta_t = v_t/u_t$. A * denotes a targeted second moment.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

Figure E7. Cyclical Firm and Labor Market Dynamics: Leads and Lags with Output, Data vs. Benchmark Model under Baseline Calibration and Model with Endogenous Job Search During Temporary Layoff



Note: The firm survival rate (Firm Surv. Rate) is computed as 1 minus the firm death rate using data from the BLS Business Employment Dynamics database. Unempl. Rate is the civilian unemployment rate, Temp. Layoffs (TL) is the number of individuals on temporary layoff, and the TL-Unempl. Share is the share of temporary layoffs in total unemployment. The data in this table spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics) except for vacancies and market tightness, which span 2001Q1-2019Q3 due to the time series on vacancies. See Appendix B.B1 for variable definitions, sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (when appropriate) and a Hodrick-Prescott (HP) filter with smoothing parameter 1600. To compare the model to the data, in the benchmark model in period t, firm births in are given by N_{Et} while the firm survival rate is $(1 - G(z_{at}))$. The red square marks a targeted second moment.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

E4. Model with Endogenous Permanent Separations from Temporary Layoff

Changes to Benchmark Model. — In what follows, we describe the components of the benchmark model that change when we introduce endogenous permanent separations from temporary layoff only.

In addition to obtaining savings a from placing active workers on temporary layoff, incurring a fixed cost e associated with new vacancy creation, and incurring a fixed cost ζ to recall a worker on temporary layoff back to the firm, the representative intermediate goods firm also incurs a cost o to maintain matches with workers on temporary layoff. This cost is drawn from an *i.i.d.* distribution $Q(o)$. Defining $\widetilde{o}_t$ as the endogenous threshold for the cost o below which the intermediate goods firm maintains a match, the endogenous probability with which a match with a worker on temporary layoff survives is $q_{o,t} = Q(\widetilde{o}_t)$ where $\partial q_{o,t}/\partial \widetilde{o}_t > 0$.

Perceived Evolution of Active Employment, Temporary Layoffs, and Vacancies: Intermediate Goods Firm. — The perceived law of motion for active workers is given by

$$n_{at} = (1 - \rho_n)(1 - q_{at})n_{at-1} + q_{rt}q_{ot}n_{it-1} + v_t q_t,$$

which takes into account that, with exogenous probability probability $0 < (1 - \rho_n) < 1$ an active worker remains matched with the firm, with endogenous probability q_{at} the firm's active workers from last period move to temporary layoff, with endogenous probability $0 < q_{ot} < 1$ a match currently on temporary layoff survives and is not permanently destroyed, and with endogenous probability q_{rt} workers that have thus far been on temporary layoff are recalled back to the firm.

The perceived law of motion for the measure of workers on temporary layoff is

$$n_{it} = (1 - q_{rt})q_{ot}n_{it-1} + q_{at}(1 - \rho_n) n_{at-1},$$

Finally, the evolution of total job vacancies is

$$v_t = (1 - \rho_v)(1 - q_{t-1})v_{t-1} + \rho_n n_{at-1} + q_{at}(1 - \rho_n) n_{at-1} + v_{nt},$$

where we maintain the same baseline assumptions regarding the evolution of total vacancies as those in the benchmark model.

Intermediate Goods Firm Value Function. — With the above information in mind, the value function for the intermediate goods firm is

$$\mathbf{J}(n_{at-1}, n_{it-1}, v_{t-1}, Z_t) = \max_{\{n_{at}, n_{it}, v_t, \widetilde{a}_t, \widetilde{\zeta}_t, \widetilde{e}_t, \widetilde{o}_t\}} \begin{bmatrix} mc_t Z_t n_{at} - w_t n_{at} - \gamma v_t - \int_0^{\widetilde{e}_t} edF(e) \\ + (1-\rho_n)\, n_{at-1} \left(\int_0^{\widetilde{a}_t} adH(a) \right) \\ -\chi_i n_{it} - q_{ot} n_{it-1} \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) \right) \\ - \left(\int_0^{\widetilde{o}_t} odQ(o) \right) n_{it} \\ + E_t \Xi_{t+1|t} \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1}) \end{bmatrix},$$

where $\Xi_{t+1|t}$ is the stochastic discount factor between period t and period $t+1$, n_{at} is the measure of workers who participate in production—that is, the measure of *a*ctive workers—v_t denotes total job vacancies, and n_{it} is the measure of workers on temporary layoff—that is, the measure of *i*nactive workers or simply workers on temporary layoff. Each active worker in period t generates real revenue $mc_t Z_t$, where Z_t denotes exogenous aggregate productivity and mc_t is the real price of intermediate goods, and receives a real wage w_t. The term $\int_0^{\widetilde{e}_t} edF(e)$ represents the total fixed cost associated with the general new-worker recruiting process, and $\widetilde{e}_t$ is the endogenous threshold for the fixed cost of new-worker recruiting.

Remember that the endogenous probability that a worker—whether active or on temporary layoff—remains matched with the firm is q_{ot}, so that $(1 - q_{ot})$ is the endogenous probability of permanent separation from the firm. Moreover, q_{ot} depends on the endogenous threshold for the resource cost below which the firm chooses to keep a match, $\widetilde{o}_t$. Then, the total resource cost of maintaining a match is $\left(\int_0^{\widetilde{o}_t} odQ(o)\right)(n_{at} + n_{it})$. Given q_{ot}, the term $q_{ot} n_{at-1} \left(\int_0^{\widetilde{a}_t} adH(a)\right)$ represents the total resource savings associated with placing surviving active workers on temporary layoff, where the term $\int_0^{\widetilde{a}_t} adH(a)$ already incorporates the probability of placing a worker on temporary layoff, while the term $q_{ot} n_{it-1} \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta)\right)$ represents the total resource cost associated with recalling surviving workers currently on temporary layoff back to the firm, where similarly the term $\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta)$ already incorporates the probability that a worker on temporary layoff returns to the firm.

Similar to Leduc and Liu (2020, 2023), given that new vacancies v_{nt} are subject to a fixed cost e drawn from distribution $F(e)$ and that $\widetilde{e}_t$ is the endogenous threshold cost below which a firm posts a new vacancy, we can express new vacancies as a function of $\widetilde{e}_t$ by using the CDF of e evaluated at the threshold $\widetilde{e}_t$, that is, $v_{nt} = F(\widetilde{e}_t)$. Making use of this last expression and denoting the multipliers on the firm's perceived evolution of active employment n_{at}, workers on temporary layoff n_{it}, and total vacancies v_t by μ_{at}, μ_{it}, and μ_{vt}, respectively, we can write the value function of the intermediate goods firm inclusive of the constraints it faces as:

$$\mathbf{J}(n_{at-1}, n_{it-1}, v_{t-1}, Z_t) = \max_{\{n_{at}, n_{it}, v_t, \widetilde{a}_t, \widetilde{\zeta}_t, \widetilde{e}_t, \widetilde{o}_t\}} \left[\begin{array}{c} mc_t Z_t n_{at} - w_t n_{at} - \gamma v_t - \int_0^{\widetilde{e}_t} e dF(e) \\ + (1-\rho_n)\, n_{at-1} \left(\int_0^{\widetilde{a}_t} a dH(a) \right) \\ -\chi_i n_{it} - q_{ot} n_{it-1} \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) \right) \\ - \left(\int_0^{\widetilde{o}_t} o dQ(o) \right) n_{it} \\ + E_t \Xi_{t+1|t} \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1}) \\ + \mu_{at} [(1-\rho_n)(1-q_{at}) n_{at-1} \\ v_t q_t + q_{ot} q_{rt} n_{it-1} - n_{at}] \\ + \mu_{it} [q_{ot}(1-q_{rt}) n_{it-1} + (1-\rho_n) q_{at} n_{at-1} - n_{it}] \\ + \mu_{vt} [[(1-\rho_v)(1-q_{t-1}) v_{t-1}] \\ + n_{at-1} (\rho_n + (1-\rho_n) q_{at}) + F(\widetilde{e}_t) - v_t] \end{array} \right],$$

First, consider the envelope conditions:

$$\frac{\partial \mathbf{J}_t(n_{at-1}, n_{it-1}, v_{t-1}, Z_t)}{\partial n_{at-1}} = (1-\rho_n) \left(\mu_{at}(1-q_{at}) + \mu_{it} q_{at} + \int_0^{\widetilde{a}_t} a dH(a) \right) + \mu_{vt} (\rho_n + (1-\rho_n) q_{at}),$$

$$\frac{\partial \mathbf{J}_t(n_{at-1}, n_{it-1}, v_{t-1}, Z_t)}{\partial n_{it-1}} = q_{ot} \left(\mu_{at} q_{rt} + \mu_{it} (1-q_{rt}) - \int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) \right),$$

and

$$\frac{\partial \mathbf{J}_t(n_{at-1}, n_{it-1}, v_{t-1}, Z_t)}{\partial v_{t-1}} = \mu_{vt}(1-\rho_v)(1-q_{t-1}).$$

With these conditions in mind, the firm's choices over active employment n_{at}, workers on temporary layoff n_{it}, and the endogenous thresholds $\widetilde{a}_t, \widetilde{\zeta}_t, \widetilde{e}_t$, and $\widetilde{o}_t$ are

$$mc_t Z_t - w_t - \mu_{at} + E_t \Xi_{t+1|t} \frac{\partial \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1})}{\partial n_{at}} = 0,$$

$$-\chi_i - \int_0^{\widetilde{o}_t} o dQ(o) - \mu_{it} + E_t \Xi_{t+1|t} \frac{\partial \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1})}{\partial n_{it}} = 0,$$

$$\gamma + \mu_{at} q_t - \mu_{vt} + E_t \Xi_{t+1|t} \frac{\partial \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1})}{\partial v_t} = 0,$$

$$q_{ot} n_{at-1} \frac{\partial q_{at}}{\partial \widetilde{a}_t} \widetilde{a}_t - \mu_{at} q_{ot} n_{at-1} \frac{\partial q_{at}}{\partial \widetilde{a}_t} + \mu_{it} q_{ot} n_{at-1} \frac{\partial q_{at}}{\partial \widetilde{a}_t} + \mu_{vt} q_{ot} n_{at-1} \frac{\partial q_{at}}{\partial \widetilde{a}_t} = 0,$$

$$-q_{ot} n_{it-1} \frac{\partial q_{rt}}{\partial \widetilde{\zeta}_t} \widetilde{\zeta}_t + \mu_{at} q_{ot} n_{it-1} \frac{\partial q_{rt}}{\partial \widetilde{\zeta}_t} - \mu_{it} q_{ot} n_{it-1} \frac{\partial q_{rt}}{\partial \widetilde{\zeta}_t} = 0,$$

$$-\frac{\partial F(\widetilde{e}_t)}{\partial \widetilde{e}_t} \widetilde{e}_t + \mu_{vt} \frac{\partial F(\widetilde{e}_t)}{\partial \widetilde{e}_t} = 0,$$

and

$$n_{it-1} \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) \right) \frac{\partial q_{ot}}{\partial \widetilde{o}_t} - \frac{\partial q_{ot}}{\partial \widetilde{o}_t} \widetilde{o}_t n_{it} + \mu_{at} \frac{\partial q_{ot}}{\partial \widetilde{o}_t} q_{rt} n_{it-1} + \mu_{it} \frac{\partial q_{ot}}{\partial \widetilde{o}_t} (1 - q_{rt}) n_{it-1} = 0.$$

Defining $\mu_{vt} \equiv \mathbf{J}_{vt}$, $\mu_{at} \equiv \mathbf{J}_{at}$, and $\mu_{it} \equiv \mathbf{J}_{it}$, and using the envelope conditions derived above in $t+1$, we can then write the optimality conditions for n_{at}, n_{it}, and v_t as

$$\begin{aligned} \mathbf{J}_{at} =& mc_t Z_t - w_t - \int_0^{\widetilde{o}_t} odQ(o) + (1-\rho_n) E_t \left\{ \Xi_{t+1|t} (1 - q_{at+1}) \mathbf{J}_{at+1} \right\} \\ &+ (1-\rho_n) E_t \left\{ \Xi_{t+1|t} \left[\left(q_{at+1} \mathbf{J}_{it+1} + \int_0^{\widetilde{a}_{t+1}} adH(a) \right) \right] \right\} \\ &+ E_t \left\{ \Xi_{t+1|t} (\rho_n + (1-\rho_n) q_{at+1}) \mathbf{J}_{vt+1} \right\}, \end{aligned} \tag{E1}$$

$$\begin{aligned} \mathbf{J}_{it} =& -\chi_i - \int_0^{\widetilde{o}_t} odQ(o) + E_t \left\{ \Xi_{t+1|t} q_{ot+1} (1 - q_{rt+1}) \mathbf{J}_{it+1} \right\} \\ &+ E_t \left\{ \Xi_{t+1|t} q_{ot+1} \left(q_{rt+1} \mathbf{J}_{at+1} - \int_0^{\widetilde{\zeta}_{t+1}} \zeta dR(\zeta) \right) \right\}, \end{aligned} \tag{E2}$$

and

$$\mathbf{J}_{vt} = -\gamma + q_t \mathbf{J}_{at} + (1-\rho_v)(1-q_t) E_t \left\{ \Xi_{t+1|t} \mathbf{J}_{vt+1} \right\},$$

and express the optimal thresholds $\widetilde{a}_t, \widetilde{\zeta}_t$, and $\widetilde{e}_t$ as

$$\widetilde{a}_t = (\mathbf{J}_{at} - \mathbf{J}_{it} - \mathbf{J}_{vt}),$$

$$\widetilde{\zeta}_t = (\mathbf{J}_{at} - \mathbf{J}_{it}),$$
$$\widetilde{e}_t = \mathbf{J}_{vt},$$

As was the case in the benchmark model, given the optimality condition $\widetilde{e}_t = \mathbf{J}_{vt}$, it follows that we can write new vacancies as $v_{n,t} = F(\widetilde{e}_t) = F(\mathbf{J}_{v,t})$.

Finally, after rearranging terms, the optimal threshold $\widetilde{o}_t$ can be expressed as:

$$\widetilde{o}_t = \left(q_{rt}(\mathbf{J}_{at} - \mathbf{J}_{it}) - \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) \right) + \mathbf{J}_{it} \right) \left(\frac{n_{it-1}}{n_{it}} \right).$$

Note that in the absence of temporary layoffs, this expression collapses to $\widetilde{o}_t = 0$. The expression for $\widetilde{o}_t$ is the presence of temporary layoffs considers the weighted net marginal benefit of maintaining a match on temporary layoff.

Wage Determination. — The period-t real wage is given by

$$w_t = (w^*)^{\gamma_w} (w_{nt})^{1-\gamma_w},$$

where w_{nt} is the period-t Nash-bargained real wage, w^* is the Nash-bargained real wage in the steady state, and parameter $0 \leq \gamma_w < 1$ governs the degree of wage rigidity (see Sedlácek, 2020, for a similar specification). In turn, denoting by $0 < \eta < 1$ the worker's bargaining power, the period-t Nash real wage w_{nt} is implicitly given by

$$w_{nt} - \chi_u + (1-\rho_n) E_t \left\{ \Xi_{t+1|t} (1 - q_{at+1} - f_{t+1}) \left(\frac{\eta}{1-\eta} \right) (\mathbf{J}_{at+1} - \mathbf{J}_{vt+1}) \right\}$$
$$+ (1-\rho_n) E_t \left\{ \Xi_{t+1|t} q_{at+1} \mathbf{W}_{it+1} \right\} = \left(\frac{\eta}{1-\eta} \right) (\mathbf{J}_{at} - \mathbf{J}_{vt}),$$

where

$$\mathbf{W}_{at} = (w_t - \chi_u) + (1-\rho_n) E_t \left\{ \Xi_{t+1|t} (1 - q_{at+1} - f_{t+1}) \mathbf{W}_{at+1} \right\}$$
$$+ (1-\rho_n) E_t \left\{ \Xi_{t+1|t} q_{at+1} \mathbf{W}_{it+1} \right\},$$

and

$$\mathbf{W}_{it} = \chi_i + E_t \left\{ \Xi_{t+1|t} q_{ot+1} (q_{rt+1} - f_{t+1}) \mathbf{W}_{at+1} \right\}$$
$$+ E_t \left\{ \Xi_{t+1|t} q_{ot+1} (1 - q_{rt+1}) \mathbf{W}_{it+1} \right\}.$$

Symmetric Equilibrium and Market Clearing. — The aggregate resource constraint is given by

$$Y_t = c_t + \gamma v_t + f_{Et} N_{Et} + f_a N_t + \int_0^{\widetilde{e}_t} e dF(e) + \Lambda_t,$$

where

$$\begin{aligned}\Lambda_t \equiv &(1-\rho_i) n_{it-1} \int_0^{\widetilde{\zeta}} \zeta dR(\zeta) - (1-\rho_n) n_{at-1} \int_0^{\widetilde{a}} a dH(a) \\ &- \int_0^{\widetilde{o}} o dQ(o) n_{it}.\end{aligned}$$

Quantitative Results. — We adopt the same baseline calibration targets as those in the benchmark model. We assume that $Q(o_t) = (o_t/\overline{o})^{\eta_o}$, where parameters $\overline{o}, \eta_o > 0$. Similar to our baseline assumptions for the probabilities of placing a worker on temporary layoff and recalling a worker on temporary layoff, we set $\eta_o = 1$. Noting that $q_{ot} = Q(o_t)$, we choose $q(o_t) = 0.90$ as a first-moment target to calibrate $\overline{o}$. This target implies a permanent job separation rate from temporary layoff of 0.10, which is consistent with the baseline calibration of the benchmark model.

Table E3 shows a version of Table 4 in the main text where we assume that the transition from temporary layoff to permanent separation is endogenous. Figure E8 compares the lag-lead structure in the benchmark model and in the model with endogenous permanent separations from temporary layoff to the data. Figure E9 shows the counterpart of Figure 4 in the main text for the model with endogenous permanent separations from temporary layoff.

TABLE E3—CYCLICAL FIRM AND LABOR MARKET DYNAMICS: DATA VS. BENCHMARK MODEL AND MODEL WITH ENDOGENOUS PERMANENT SEPARATIONS FROM TEMPORARY LAYOFF ONLY

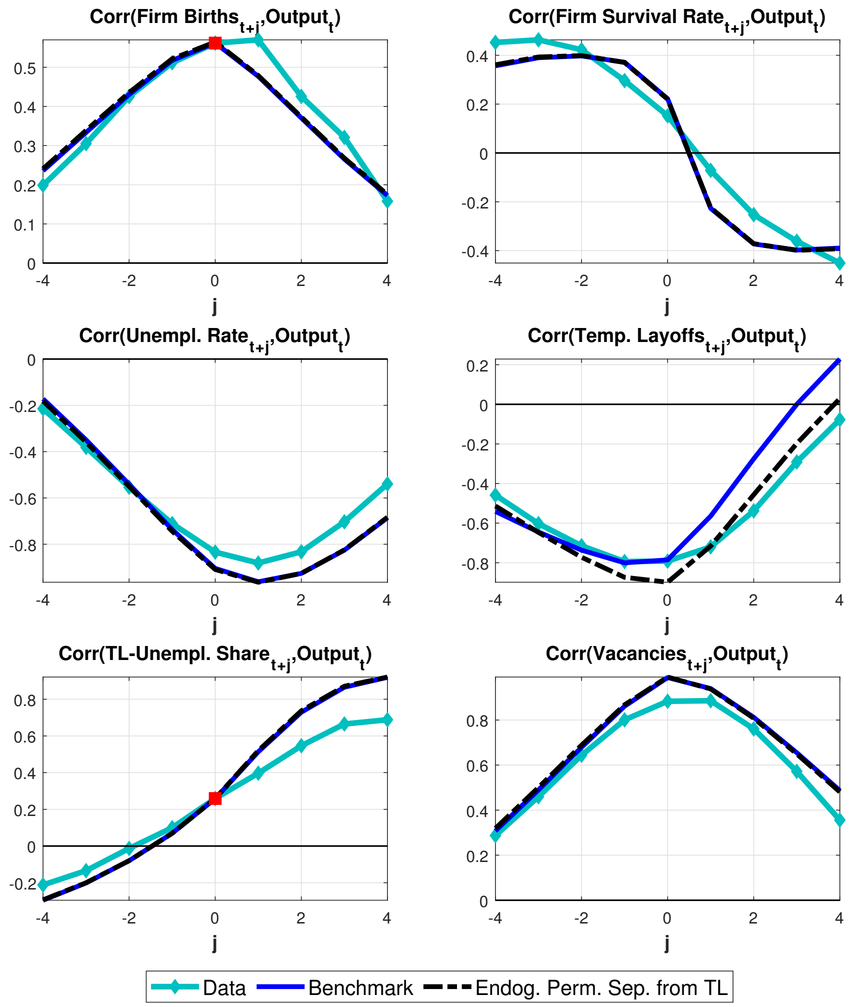
	Relative Standard Deviation						
	Firm Births	Firm Surv. Rate	Unempl. Rate	Temp. Layoffs (TL)	TL–Unempl. Share	Vacancies	Market Tightness
Data	**3.37**	**0.13**	**11.34**	**9.20**	**6.60**	**11.87**	**23.26**
Benchmark	**2.80**	**0.70**	**6.77**	**5.66**	**6.45**	**3.56**	**10.22**
End. Per. Sep. n_i	**2.89**	**0.74**	**5.57**	**4.47**	**5.80**	**2.83**	**8.35**

	Contemporaneous Correlation with Output						
	Firm Births	Firm Surv. Rate	Unempl. Rate	Temp. Layoffs (TL)	TL–Unempl. Share	Vacancies	Market Tightness
Data	**0.561**	**0.152**	**–0.834**	**–0.792**	**0.259**	**0.883**	**0.899**
Benchmark	**0.561***	**0.222**	**–0.904**	**–0.786**	**0.259***	**0.989**	**0.943**
End. Per. Sep. n_i	**0.561***	**0.232**	**–0.867**	**–0.744**	**0.259***	**0.959**	**0.904**

	First-Order Autocorrelation						
	Firm Births	Firm Surv. Rate	Unempl. Rate	Temp. Layoffs (TL)	TL–Unempl. Share	Vacancies	Market Tightness
Data	**0.381**	**0.489**	**0.943**	**0.769**	**0.654**	**0.914**	**0.934**
Benchmark	**0.762**	**0.328**	**0.954**	**0.883**	**0.947**	**0.922**	**0.946**
End. Per. Sep. n_i	**0.761**	**0.298**	**0.955**	**0.895**	**0.959**	**0.931**	**0.949**

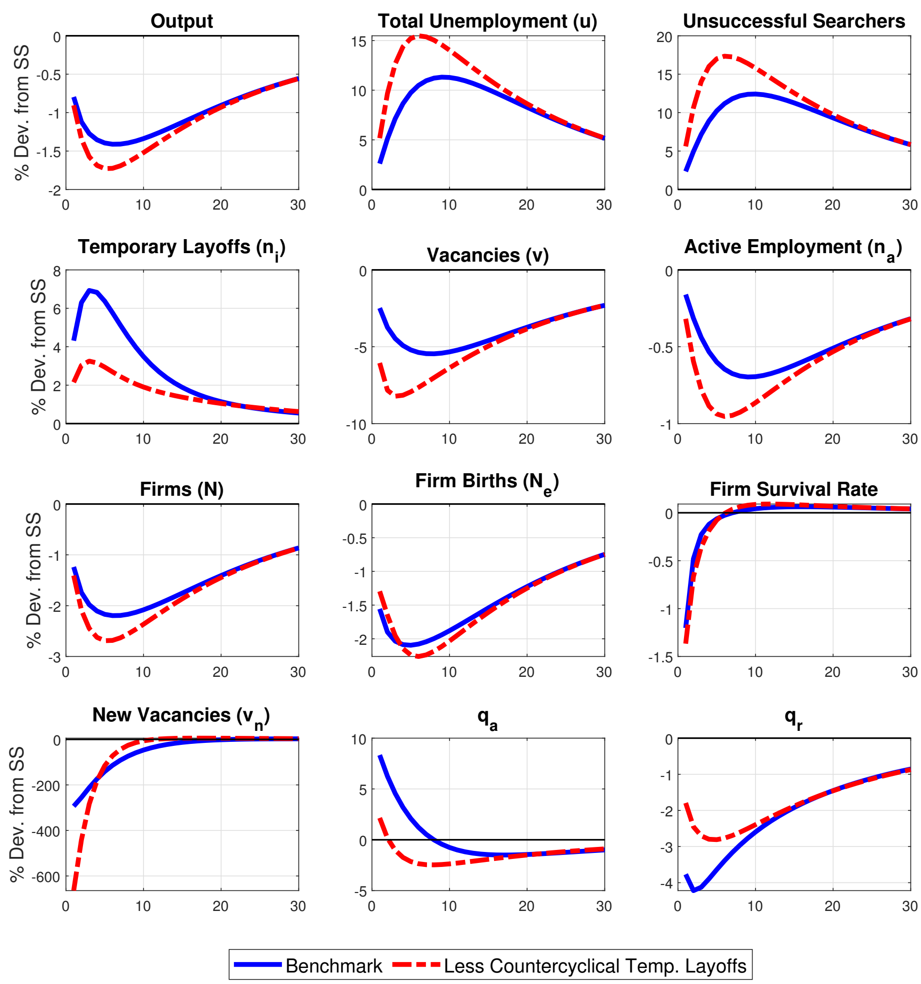
Note: The relative standard deviation is the standard deviation of a variable relative to the standard deviation of real GDP. The firm survival rate (Firm Surv. Rate) is computed as 1 minus the firm death rate using data from the BLS Business Employment Dynamics database. Unempl. Rate is the civilian unemployment rate, Temp. Layoffs (TL) is the number of individuals on temporary layoff, and the TL-Unempl. Share is the share of temporary layoffs in total unemployment. The data in this table spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics) except for vacancies and market tightness, which span 2001Q1-2019Q3 due to the time series on vacancies. See Appendix B.B1 for variable definitions, sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (when appropriate) and a Hodrick-Prescott (HP) filter with smoothing parameter 1600. To compare the model to the data, in the benchmark model in period t, firm births are given by N_{Et} while the firm survival rate is $(1 - G(z_{at}))$. The model counterpart of market tightness in the data is $\Theta_t = v_t/u_t$. A * denotes a targeted second moment.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

FIGURE E8. CYCLICAL FIRM AND LABOR MARKET DYNAMICS: LEADS AND LAGS WITH OUTPUT, DATA VS. BENCHMARK MODEL WITH ENDOGENOUS PERMANENT SEPARATIONS FROM TEMPORARY LAYOFF ONLY



Note: The firm survival rate (Firm Surv. Rate) is computed as 1 minus the firm death rate using data from the BLS Business Employment Dynamics database. Unempl. Rate is the civilian unemployment rate, Temp. Layoffs (TL) is the number of individuals on temporary layoff, and the TL-Unempl. Share is the share of temporary layoffs in total unemployment. The data in this table spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics) except for vacancies and market tightness, which span 2001Q1-2019Q3 due to the time series on vacancies. See Appendix B.B1 for variable definitions, sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (when appropriate) and a Hodrick-Prescott (HP) filter with smoothing parameter 1600. To compare the model to the data, in the benchmark model in period t, firm births in are given by N_{Et} while the firm survival rate is $(1 - G(z_{at}))$. The red square marks a targeted second moment.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

Figure E9. Impulse Response Functions to a One-Standard-Deviation Adverse Aggregate Productivity (Z_t) Shock in Version of Model with Endogenous Permanent Separations from Temporary Layoff Only



Note: The x axis denotes quarters after the shock. Unemployed searchers in period t are given by $(1-f_t)s_t$ while total unemployment includes temporary layoffs n_{it} and is given by $u_t = (1-f_t)s_t + n_{it}$. Firm births and the firm survival rate in period t are given by N_{Et} and $(1-G(z_{at}))$, respectively.

E5. Model with Endogenous Permanent Separations from Active Employment and from Temporary Layoff

Changes to Benchmark Model. — In what follows, we only describe the components of the benchmark model that change when we introduce endogenous permanent separations from both active employment and from temporary layoff.

In addition to obtaining savings a from placing active workers on temporary layoff, incurring a fixed cost e associated with new vacancy creation, and incurring a fixed cost ζ to recall a worker on temporary layoff back to the firm, the representative intermediate goods firm also incurs a cost o to maintain matches with active workers and workers on temporary layoff. This cost is drawn from an *i.i.d.* distribution $Q(o)$. Defining $\widetilde{o}_t$ as the endogenous threshold for the cost o below which the intermediate goods firm maintains a match, the endogenous probability with which a match (whether it is with an active worker or with a worker on temporary layoff) survives is $q_{o,t} = Q(\widetilde{o}_t)$ where $\partial q_{o,t}/\partial\widetilde{o}_t > 0$.

Perceived Evolution of Active Employment, Temporary Layoffs, and Vacancies: Intermediate Goods Firm. — The perceived law of motion for active workers is given by

$$n_{at} = (1 - q_{at})q_{ot}n_{at-1} + q_{rt}q_{ot}n_{it-1} + v_t q_t, \tag{E3}$$

which takes into account that, with *endogenous* probability $0 < q_{ot} < 1$ an active worker remains matched with the firm (i.e., q_{ot} is the probability that the match survives and is not permanently destroyed), with endogenous probability q_{at} the firm's active workers from last period move to temporary layoff, and with endogenous probability q_{rt} workers that have thus far been on temporary layoff are recalled back to the firm (if the match with the firm survives permanent destruction with endogenous probability q_{ot}).

The perceived law of motion for the measure of workers on temporary layoff is

$$n_{it} = (1 - q_{rt})q_{ot}n_{it-1} + q_{at}q_{ot}n_{at-1}, \tag{E4}$$

Finally, the evolution of total job vacancies is

$$v_t = (1 - \rho_v)(1 - q_{t-1})v_{t-1} + (1 - q_{ot})\, n_{at-1} + q_{at}q_{ot}n_{at-1} + v_{nt}, \tag{E5}$$

where we maintain the same baseline assumptions regarding the evolution of total vacancies as those in the benchmark model.

Intermediate Goods Firm Value Function. — With the above information in mind, the value function for the intermediate goods firm is

$$\mathbf{J}(n_{at-1}, n_{it-1}, v_{t-1}, Z_t) = \max_{\{n_{at}, n_{it}, v_t, \widetilde{a}_t, \widetilde{\zeta}_t, \widetilde{e}_t, \widetilde{o}_t\}} \begin{bmatrix} mc_t Z_t n_{at} - w_t n_{at} - \gamma v_t - \int_0^{\widetilde{e}_t} edF(e) \\ +q_{ot} n_{at-1} \left(\int_0^{\widetilde{a}_t} adH(a) \right) \\ -\chi_i n_{it} - q_{ot} n_{it-1} \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) \right) \\ - \left(\int_0^{\widetilde{o}_t} odQ(o) \right) (n_{at} + n_{it}) \\ +E_t \Xi_{t+1|t} \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1}) \end{bmatrix},$$

where $\Xi_{t+1|t}$ is the stochastic discount factor between period t and period $t+1$, n_{at} is the measure of workers who participate in production—that is, the measure of *a*ctive workers—v_t denotes total job vacancies, and n_{it} is the measure of workers on temporary layoff—that is, the measure of *i*nactive workers or simply workers on temporary layoff. Each active worker in period t generates real revenue $mc_t Z_t$, where Z_t denotes exogenous aggregate productivity and mc_t is the real price of intermediate goods, and receives a real wage w_t. The term $\int_0^{\widetilde{e}_t} edF(e)$ represents the total fixed cost associated with the general new-worker recruiting process, and $\widetilde{e}_t$ is the endogenous threshold for the fixed cost of new-worker recruiting.

Remember that the endogenous probability that a worker—whether active or on temporary layoff—remains matched with the firm is q_{ot}, so that $(1 - q_{ot})$ is the endogenous probability of permanent separation from the firm. Moreover, q_{ot} depends on the endogenous threshold for the resource cost below which the firm chooses to keep a match, $\widetilde{o}_t$. Then, the total resource cost of maintaining a match is $\left(\int_0^{\widetilde{o}_t} odQ(o)\right)(n_{at} + n_{it})$. Given q_{ot}, the term $q_{ot} n_{at-1} \left(\int_0^{\widetilde{a}_t} adH(a)\right)$ represents the total resource savings associated with placing surviving active workers on temporary layoff, where the term $\int_0^{\widetilde{a}_t} adH(a)$ already incorporates the probability of placing a worker on temporary layoff, while the term $q_{ot} n_{it-1} \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta)\right)$ represents the total resource cost associated with recalling surviving workers currently on temporary layoff back to the firm, where similarly the term $\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta)$ already incorporates the probability that a worker on temporary layoff returns to the firm.

Similar to Leduc and Liu (2020, 2023), given that new vacancies v_{nt} are subject to a fixed cost e drawn from distribution $F(e)$ and that $\widetilde{e}_t$ is the endogenous threshold cost below which a firm posts a new vacancy, we can express new vacancies as a function of $\widetilde{e}_t$ by using the CDF of e evaluated at the threshold $\widetilde{e}_t$, that is, $v_{nt} = F(\widetilde{e}_t)$. Making use of this last expression and denoting the multipliers on the firm's perceived evolution of active employment n_{at}, workers on temporary layoff n_{it}, and total vacancies v_t by μ_{at}, μ_{it}, and μ_{vt}, respectively, we can write the value function of the intermediate goods firm inclusive of the constraints it faces as:

$$\mathbf{J}(n_{at-1}, n_{it-1}, v_{t-1}, Z_t) = \underset{\{n_{at}, n_{it}, v_t, \widetilde{a}_t, \widetilde{\zeta}_t, \widetilde{e}_t, \widetilde{o}_t\}}{max} \begin{bmatrix} mc_t Z_t n_{at} - w_t n_{at} - \gamma v_t - \int_0^{\widetilde{e}_t} edF(e) \\ +q_{ot} n_{at-1} \left(\int_0^{\widetilde{a}_t} adH(a) \right) \\ -\chi_i n_{it} - q_{ot} n_{it-1} \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) \right) \\ - \left(\int_0^{\widetilde{o}_t} odQ(o) \right) (n_{at} + n_{it}) \\ +E_t \Xi_{t+1|t} \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1}) \\ +\mu_{at}[q_{ot}(1 - q_{at}) n_{at-1} \\ v_t q_t + q_{ot} q_{rt} n_{it-1} - n_{at}] \\ +\mu_{it} \left[q_{ot}(1 - q_{rt}) n_{it-1} + q_{ot} q_{at} n_{at-1} - n_{it} \right] \\ +\mu_{vt} \left[[(1 - \rho_v)(1 - q_{t-1}) v_{t-1} \right] \\ +n_{at-1} \left((1 - q_{ot}) + q_{ot} q_{at} \right) + F(\widetilde{e}_t) - v_t] \end{bmatrix},$$

First, consider the envelope conditions:

$$\frac{\partial \mathbf{J}_t(n_{at-1}, n_{it-1}, v_{t-1}, Z_t)}{\partial n_{at-1}} = q_{ot} \left(\mu_{at}(1 - q_{at}) + \mu_{it} q_{at} + \int_0^{\widetilde{a}_t} adH(a) \right) + \mu_{vt} \left((1 - q_{ot}) + q_{ot} q_{at} \right),$$

$$\frac{\partial \mathbf{J}_t(n_{at-1}, n_{it-1}, v_{t-1}, Z_t)}{\partial n_{it-1}} = q_{ot} \left(\mu_{at} q_{rt} + \mu_{it} \left(1 - q_{rt}\right) - \int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) \right),$$

and

$$\frac{\partial \mathbf{J}_t(n_{at-1}, n_{it-1}, v_{t-1}, Z_t)}{\partial v_{t-1}} = \mu_{vt}(1 - \rho_v) \left(1 - q_{t-1}\right).$$

With these conditions in mind, the firm's choices over active employment n_{at}, workers on temporary layoff n_{it}, and the endogenous thresholds $\widetilde{a}_t, \widetilde{\zeta}_t, \widetilde{e}_t$, and $\widetilde{o}_t$ are

$$mc_t Z_t - w_t - \int_0^{\widetilde{o}_t} odQ(o) - \mu_{at} + E_t \Xi_{t+1|t} \frac{\partial \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1})}{\partial n_{at}} = 0,$$

$$-\chi_i - \int_0^{\widetilde{o}_t} odQ(o) - \mu_{it} + E_t\Xi_{t+1|t}\frac{\partial \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1})}{\partial n_{it}} = 0,$$
$$\gamma + \mu_{at}q_t - \mu_{vt} + E_t\Xi_{t+1|t}\frac{\partial \mathbf{J}_{t+1}(n_{at}, n_{it}, v_t, Z_{t+1})}{\partial v_t} = 0,$$

$$\begin{aligned} &q_{ot}n_{at-1}\frac{\partial q_{at}}{\partial \widetilde{a}_t}\widetilde{a}_t - \mu_{at}q_{ot}n_{at-1}\frac{\partial q_{at}}{\partial \widetilde{a}_t} \\ &+ \mu_{it}q_{ot}n_{at-1}\frac{\partial q_{at}}{\partial \widetilde{a}_t} + \mu_{vt}q_{ot}n_{at-1}\frac{\partial q_{at}}{\partial \widetilde{a}_t} = 0, \end{aligned}$$

$$-q_{ot}n_{it-1}\frac{\partial q_{rt}}{\partial \widetilde{\zeta}_t}\widetilde{\zeta}_t + \mu_{at}q_{ot}n_{it-1}\frac{\partial q_{rt}}{\partial \widetilde{\zeta}_t} - \mu_{it}q_{ot}n_{it-1}\frac{\partial q_{rt}}{\partial \widetilde{\zeta}_t} = 0,$$
$$-\frac{\partial F(\widetilde{e}_t)}{\partial \widetilde{e}_t}\widetilde{e}_t + \mu_{vt}\frac{\partial F(\widetilde{e}_t)}{\partial \widetilde{e}_t} = 0,$$

and

$$\begin{aligned} &n_{at-1}\left(\int_0^{\widetilde{a}_t} adH(a)\right)\frac{\partial q_{ot}}{\partial \widetilde{o}_t} - n_{it-1}\left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta)\right)\frac{\partial q_{ot}}{\partial \widetilde{o}_t} \\ &-\frac{\partial q_{ot}}{\partial \widetilde{o}_t}\widetilde{o}_t\left(n_{at} + n_{it}\right) + \mu_{at}\frac{\partial q_{ot}}{\partial \widetilde{o}_t}\left((1-q_{at})n_{at-1} + q_{rt}n_{it-1}\right) \\ &+\mu_{it}\frac{\partial q_{ot}}{\partial \widetilde{o}_t}\left(q_{at}n_{at-1} + (1-q_{rt})n_{it-1}\right) - \mu_{vt}\frac{\partial q_{ot}}{\partial \widetilde{o}_t}\left(1-q_{at}\right)n_{at-1} = 0. \end{aligned}$$

Defining $\mu_{vt} \equiv \mathbf{J}_{vt}$, $\mu_{at} \equiv \mathbf{J}_{at}$, and $\mu_{it} \equiv \mathbf{J}_{it}$, and using the envelope conditions derived above in $t+1$, we can then write the optimality conditions for n_{at}, n_{it}, and v_t as

$$\begin{aligned} \mathbf{J}_{at} =& mc_tZ_t - w_t - \int_0^{\widetilde{o}_t} odQ(o) + E_t\left\{\Xi_{t+1|t}q_{ot+1}\left(1-q_{at+1}\right)\mathbf{J}_{at+1}\right\} \\ &+ E_t\left\{\Xi_{t+1|t}\left[q_{ot+1}\left(q_{at+1}\mathbf{J}_{it+1} + \int_0^{\widetilde{a}_{t+1}} adH(a)\right)\right]\right\} \\ &+ E_t\left\{\Xi_{t+1|t}\left((1-q_{ot+1}) + q_{ot+1}q_{at+1}\right)\mathbf{J}_{vt+1}\right\}, \end{aligned} \tag{E6}$$

$$\begin{aligned} \mathbf{J}_{it} =& -\chi_i - \int_0^{\widetilde{o}_t} odQ(o) + E_t\left\{\Xi_{t+1|t}q_{ot+1}(1-q_{rt+1})\mathbf{J}_{it+1}\right\} \\ &+ E_t\left\{\Xi_{t+1|t}q_{ot+1}\left(q_{rt+1}\mathbf{J}_{at+1} - \int_0^{\widetilde{\zeta}_{t+1}} \zeta dR(\zeta)\right)\right\}, \end{aligned} \tag{E7}$$

and

$$\mathbf{J}_{vt} = -\gamma + q_t\mathbf{J}_{at} + (1-\rho_v)(1-q_t)E_t\left\{\Xi_{t+1|t}\mathbf{J}_{vt+1}\right\}, \tag{E8}$$

and express the optimal thresholds $\widetilde{a}_t, \widetilde{\zeta}_t$, and $\widetilde{e}_t$ as

$$\widetilde{a}_t = \left(\mathbf{J}_{at} - \mathbf{J}_{it} - \mathbf{J}_{vt}\right), \tag{E9}$$

$$\widetilde{\zeta}_t = \left(\mathbf{J}_{at} - \mathbf{J}_{it}\right), \tag{E10}$$

$$\widetilde{e}_t = \mathbf{J}_{vt},$$

As was the case in the benchmark model, given the optimality condition $\widetilde{e}_t = \mathbf{J}_{vt}$, it follows that we can write new vacancies as $v_{n,t} = F\left(\widetilde{e}_t\right) = F\left(\mathbf{J}_{v,t}\right)$.

Finally, after rearranging terms, the optimal threshold $\widetilde{o}_t$ can be expressed as:

$$\begin{aligned}\widetilde{o}_t = & \left[(1-q_{at})\left(\mathbf{J}_{at} - \mathbf{J}_{it} - \mathbf{J}_{vt}\right) + \int_0^{\widetilde{a}_t} a dH(a)\right]\left(\frac{n_{at-1}}{n_{at}+n_{it}}\right) \\ & + \left[q_{rt}\left(\mathbf{J}_{at} - \mathbf{J}_{it}\right) - \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta)\right)\right]\left(\frac{n_{it-1}}{n_{at}+n_{it}}\right) \\ & + \mathbf{J}_{it}\left(\frac{n_{at-1}+n_{it-1}}{n_{at}+n_{it}}\right).\end{aligned} \tag{E11}$$

Note that in the absence of temporary layoffs, this expression collapses to $\widetilde{o}_t = \left(\mathbf{J}_{at} - \mathbf{J}_{vt}\right)\left(n_{at-1}/n_{at}\right)$. That is, at the margin, the firm equates the marginal cost of maintaining an active match, $\widetilde{o}_t$, to the marginal benefit of a match, $\left(\mathbf{J}_{at} - \mathbf{J}_{vt}\right)$ and adjusted by the ratio of active employment between periods (given the fact that the cost of maintaining a match in period t is proportional to the measure of active employment in that same period). The expression for $\widetilde{o}_t$ is the presence of temporary layoffs considers the weighted net marginal benefit of maintaining a match (which can be an active match or a match on temporary layoff).

Wage Determination. — The period-t real wage is given by

$$w_t = \left(w^*\right)^{\gamma_w}\left(w_{nt}\right)^{1-\gamma_w},$$

where w_{nt} is the period-t Nash-bargained real wage, w^* is the Nash-bargained real wage in the steady state, and parameter $0 \leq \gamma_w < 1$ governs the degree of wage rigidity (see Sedlácek, 2020, for a similar specification). In turn, denoting by $0 < \eta < 1$ the worker's bargaining power, the period-t Nash real wage w_{nt} is implicitly given by

$$w_{nt} - \chi_u + E_t \left\{ \Xi_{t+1|t} q_{ot+1} \left(1 - q_{at+1} - f_{t+1}\right) \left(\frac{\eta}{1-\eta}\right) \left(\mathbf{J}_{at+1} - \mathbf{J}_{vt+1}\right) \right\}$$
$$+ E_t \left\{ \Xi_{t+1|t} q_{ot+1} q_{at+1} \mathbf{W}_{it+1} \right\} = \left(\frac{\eta}{1-\eta}\right) \left(\mathbf{J}_{at} - \mathbf{J}_{vt}\right),$$

where

$$\mathbf{W}_{at} = (w_t - \chi_u) + E_t \left\{ \Xi_{t+1|t} q_{ot+1} \left(1 - q_{at+1} - f_{t+1}\right) \mathbf{W}_{at+1} \right\}$$
$$+ E_t \left\{ \Xi_{t+1|t} q_{ot+1} q_{at+1} \mathbf{W}_{it+1} \right\},$$

and

$$\mathbf{W}_{it} = \chi_i + E_t \left\{ \Xi_{t+1|t} q_{ot+1} \left(q_{rt+1} - f_{t+1}\right) \mathbf{W}_{at+1} \right\}$$
$$+ E_t \left\{ \Xi_{t+1|t} q_{ot+1} \left(1 - q_{rt+1}\right) \mathbf{W}_{it+1} \right\}.$$

Symmetric Equilibrium and Market Clearing. — The aggregate resource constraint is given by

$$Y_t = c_t + \gamma v_t + f_{Et} N_{Et} + f_a N_t + \int_0^{\widetilde{e}_t} e dF(e) + \Lambda_t,$$

where

$$\Lambda_t \equiv (1 - \rho_i) n_{it-1} \int_0^{\widetilde{\zeta}} \zeta dR(\zeta) - (1 - \rho_n) n_{at-1} \int_0^{\widetilde{a}} a dH(a)$$
$$- \int_0^{\widetilde{o}} o dQ(o) \left(n_{at} + n_{it}\right).$$

Quantitative Results. — We adopt the same baseline calibration targets as those in the benchmark model. We assume that $Q(o_t) = (o_t/\overline{o})^{\eta_o}$, where parameters $\overline{o}, \eta_o > 0$. Similar to our baseline assumptions, we set $\eta_o = 1$. Noting that $q_{ot} = Q(o_t)$, we choose $q(o_t) = 0.90$ as a first-moment target to calibrate $\overline{o}$. This target implies a permanent job separation rate of 0.10, which is in line with the average value adopted in the search and matching literature.

For the purposes of our quantitative experiments only, a stable equilibrium requires that the resource cost of maintaining a given match (active or inactive), $\int_0^{\widetilde{o}_t} o dQ(o)$, be convex. This entails only minor modifications of the model's equilibrium conditions: instead of having $\int_0^{\widetilde{o}_t} o dQ(o)$, the cost of maintaining a given match becomes $\left(\int_0^{\widetilde{o}_t} odQ(o)\right)^{\xi_o}$, where $\xi_o > 1$. Then, the optimal choice over $\widetilde{o}_t$ becomes:

$$\xi_o \left(\int_0^{\widetilde{o}_t} odQ(o)\right)^{\xi_o - 1} \widetilde{o}_t = \left[(1-q_{at})\left(\mathbf{J}_{at} - \mathbf{J}_{it} - \mathbf{J}_{vt}\right) + \int_0^{\widetilde{a}_t} adH(a)\right]\left(\frac{n_{at-1}}{n_{at}+n_{it}}\right) + \left[q_{rt}\left(\mathbf{J}_{at} - \mathbf{J}_{it}\right) - \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta)\right)\right]\left(\frac{n_{it-1}}{n_{at}+n_{it}}\right) + \mathbf{J}_{it}\left(\frac{n_{at-1}+n_{it-1}}{n_{at}+n_{it}}\right),$$

the values to the intermediate goods firm of having an active worker and a worker on temporary layoff become:

$$\begin{aligned}\mathbf{J}_{at} =& mc_t Z_t - w_t - \left(\int_0^{\widetilde{o}_t} odQ(o)\right)^{\xi_o} + E_t\left\{\Xi_{t+1|t} q_{ot+1}\left(1-q_{at+1}\right)\mathbf{J}_{at+1}\right\} \\ &+ E_t\left\{\Xi_{t+1|t}\left[q_{ot+1}\left(q_{at+1}\mathbf{J}_{it+1} + \int_0^{\widetilde{a}_{t+1}} adH(a)\right)\right]\right\} \\ &+ E_t\left\{\Xi_{t+1|t}\left(\left(1-q_{ot+1}\right) + q_{ot+1}q_{at+1}\right)\mathbf{J}_{vt+1}\right\},\end{aligned} \tag{E12}$$

and

$$\begin{aligned}\mathbf{J}_{it} =& -\chi_i - \left(\int_0^{\widetilde{o}_t} odQ(o)\right)^{\xi_o} + E_t\left\{\Xi_{t+1|t} q_{ot+1}(1-q_{rt+1})\mathbf{J}_{it+1}\right\} \\ &+ E_t\left\{\Xi_{t+1|t} q_{ot+1}\left(q_{rt+1}\mathbf{J}_{at+1} - \int_0^{\widetilde{\zeta}_{t+1}} \zeta dR(\zeta)\right)\right\},\end{aligned} \tag{E13}$$

and the resource constraint becomes:

$$Y_t = c_t + \gamma v_t + f_{Et}N_{Et} + f_a N_t + \int_0^{\widetilde{e}_t} edF(e) + \Lambda_t,$$

where

$$\begin{aligned}\Lambda_t \equiv& (1-\rho_i)n_{it-1}\int_0^{\widetilde{\zeta}} \zeta dR(\zeta) - (1-\rho_n)n_{at-1}\int_0^{\widetilde{a}} adH(a) \\ &- \left(\int_0^{\widetilde{o}_t} odQ(o)\right)^{\xi_o}\left(n_{at}+n_{it}\right).\end{aligned}$$

We then set ξ_o to guarantee a stable equilibrium while matching the same calibration targets as those in the benchmark model and while guaranteeing procyclical total vacancies.[2]

Table E4 shows a version of Table 4 in the main text where we assume that the transition from temporary layoff to permanent separation is endogenous. Figure E10 compares the lag-lead structure in the benchmark model and in the model with endogenous permanent separations from temporary layoff to the data. Figure E11 shows the counterpart of Figure 4 in the main text for the model with endogenous permanent separations. Finally, Figure E12 shows the counterpart of Figure 6 in the main text for the models with under endogenous permanent separations.

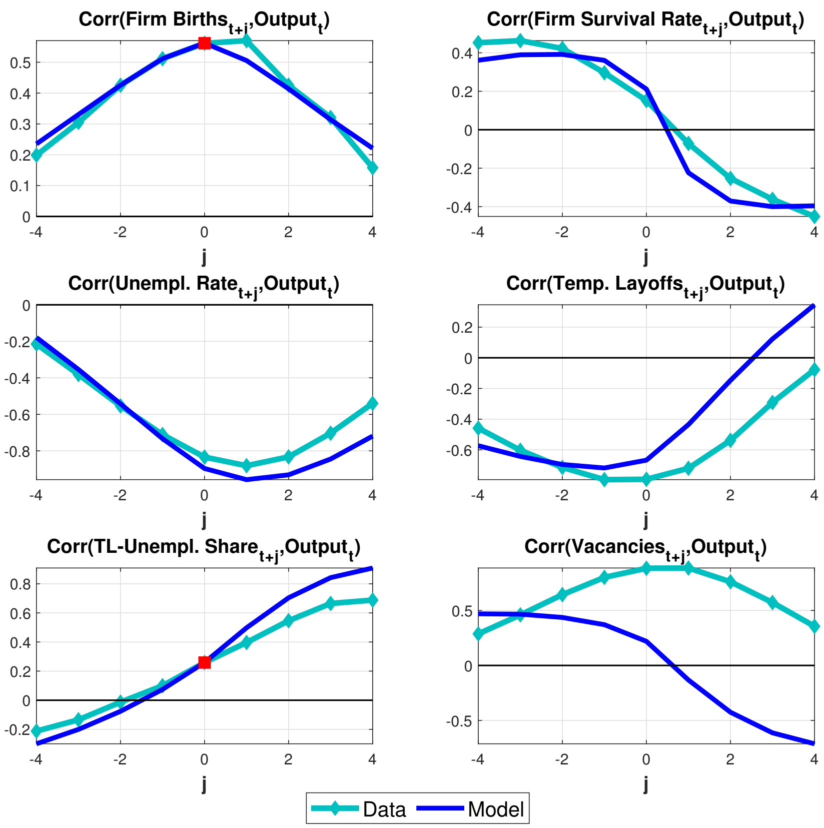
[2]Given the presence of fixed costs of new vacancy creation in the model, a high value of ξ_o can generate countercyclical total vacancies as the expansion in vacancies needed to accommodate the rise in the measure of workers placed on temporary layoff becomes strongly countercyclical and offsets the decline in new vacancies. Our calibration of ξ_o guarantees that total vacancies remain procyclical, albeit less so than in the data.

TABLE E4—CYCLICAL FIRM AND LABOR MARKET DYNAMICS: DATA VS. BENCHMARK MODEL AND MODEL WITH ENDOGENOUS PERMANENT SEPARATIONS FROM ACTIVE EMPLOYMENT AND FROM TEMPORARY LAYOFF

	Relative Standard Deviation						
	Firm Births	Firm Surv. Rate	Unempl. Rate	Temp. Layoffs (TL)	TL–Unempl. Share	Vacancies	Market Tightness
Data	**3.37**	**0.13**	**11.34**	**9.20**	**6.60**	**11.87**	**23.26**
Benchmark	**2.80**	**0.70**	**6.77**	**5.66**	**6.45**	**3.56**	**10.22**
End. Per. Sep.	**2.97**	**0.68**	**7.80**	**7.04**	**8.85**	**0.76**	**7.66**
	Contemporaneous Correlation with Output						
	Firm Births	Firm Surv. Rate	Unempl. Rate	Temp. Layoffs (TL)	TL–Unempl. Share	Vacancies	Market Tightness
Data	**0.561**	**0.152**	**–0.834**	**–0.792**	**0.259**	**0.883**	**0.899**
Benchmark	**0.561***	**0.222**	**–0.904**	**–0.786**	**0.259***	**0.989**	**0.943**
End. Per. Sep.	**0.561***	**0.211**	**–0.896**	**–0.667**	**0.259***	**0.219**	**0.935**
	First-Order Autocorrelation						
	Firm Births	Firm Surv. Rate	Unempl. Rate	Temp. Layoffs (TL)	TL–Unempl. Share	Vacancies	Market Tightness
Data	**0.381**	**0.489**	**0.943**	**0.769**	**0.654**	**0.914**	**0.934**
Benchmark	**0.762**	**0.328**	**0.954**	**0.883**	**0.947**	**0.922**	**0.946**
End. Per. Sep.	**0.774**	**0.343**	**0.958**	**0.898**	**0.956**	**0.817**	**0.950**

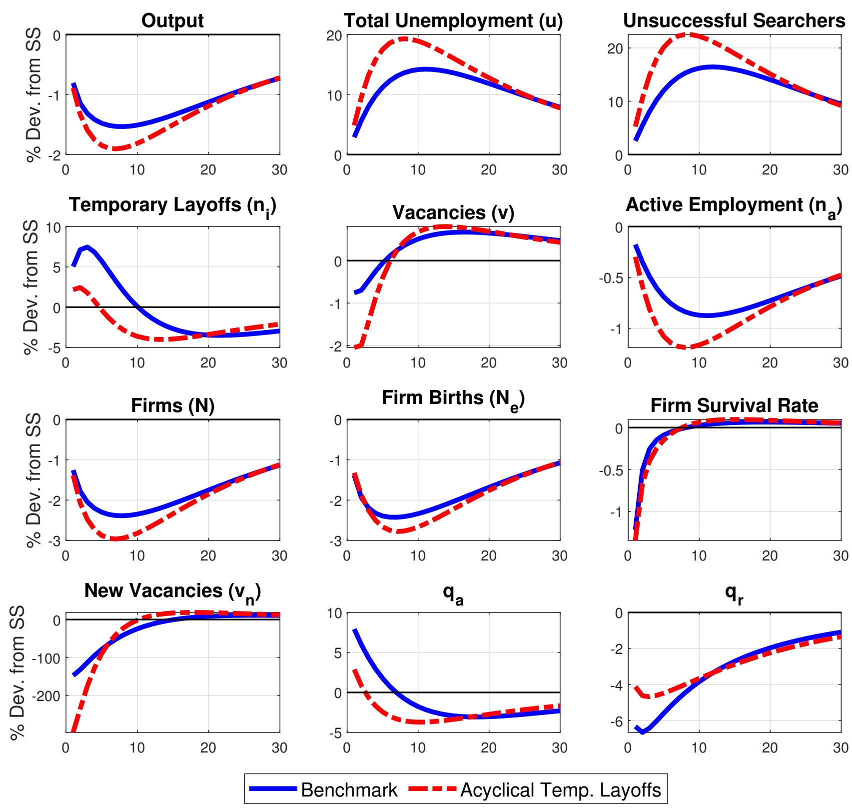
Note: The relative standard deviation is the standard deviation of a variable relative to the standard deviation of real GDP. The firm survival rate (Firm Surv. Rate) is computed as 1 minus the firm death rate using data from the BLS Business Employment Dynamics database. Unempl. Rate is the civilian unemployment rate, Temp. Layoffs (TL) is the number of individuals on temporary layoff, and the TL-Unempl. Share is the share of temporary layoffs in total unemployment. The data in this table spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics) except for vacancies and market tightness, which span 2001Q1-2019Q3 due to the time series on vacancies. See Appendix B.B1 for variable definitions, sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (when appropriate) and a Hodrick-Prescott (HP) filter with smoothing parameter 1600. To compare the model to the data, in the benchmark model in period t, firm births are given by N_{Et} while the firm survival rate is $(1 - G(z_{at}))$. The model counterpart of market tightness in the data is $\Theta_t = v_t/u_t$. A * denotes a targeted second moment.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

Figure E10. Cyclical Firm and Labor Market Dynamics: Leads and Lags with Output, Data vs. Benchmark Model with Endogenous Permanent Separations from Active Employment and from Temporary Layoff



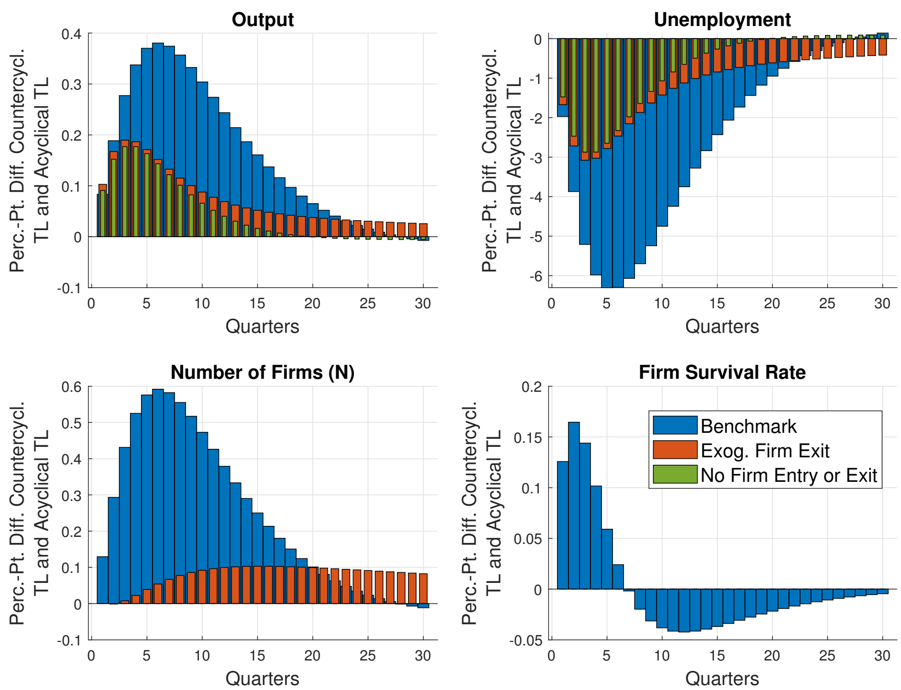
Note: The firm survival rate (Firm Surv. Rate) is computed as 1 minus the firm death rate using data from the BLS Business Employment Dynamics database. Unempl. Rate is the civilian unemployment rate, Temp. Layoffs (TL) is the number of individuals on temporary layoff, and the TL-Unempl. Share is the share of temporary layoffs in total unemployment. The data in this table spans the period 1992Q3-2019Q3 (1992Q3 is the first available data point on establishment entry and exit dynamics) except for vacancies and market tightness, which span 2001Q1-2019Q3 due to the time series on vacancies. See Appendix B.B1 for variable definitions, sources, and additional details. The cyclical component of each series is obtained by using the logged series of each variable (when appropriate) and a Hodrick-Prescott (HP) filter with smoothing parameter 1600. To compare the model to the data, in the benchmark model in period t, firm births in are given by N_{Et} while the firm survival rate is $(1 - G(z_{at}))$. The red square marks a targeted second moment.
Source: BLS Business Employment Dynamics, U.S. Census Quarterly Workforce Indicators, Saint Louis FRED Database.

Figure E11. Impulse Response Functions to a One-Standard-Deviation Adverse Aggregate Productivity (Z_t) Shock in Version of Model with Endogenous Permanent Separations from Active Employment and from Temporary Layoff



Note: The x axis denotes quarters after the shock. Unemployed searchers in period t are given by $(1-f_t)s_t$ while total unemployment includes temporary layoffs n_{it} and is given by $u_t = (1-f_t)s_t + n_{it}$. Firm births and the firm survival rate in period t are given by N_{Et} and $(1-G(z_{at}))$, respectively.

Figure E12. Differences Between Impulse Responses to Identical One-Standard-Deviation Adverse Aggregate Productivity (Z_t) Shock in Model with Countercyclical Temporary Layoffs and in Model with Acyclical Temporary Layoffs—Output, Unemployment, Firms, and Firm Survival in Benchmark Model vs. Exogenous Firm Exit vs. No Firm Entry or Exit, Models with Endogenous Permanent Separations from Active Employment and from Temporary Layoff



Note: The x axis denotes quarters after the shock and the y axis shows the percentage-point difference (Perc.-Pt. Diff.) between the impulse response of a variable under countercyclical temporary layoffs and the impulse response of the same variable under acyclical temporary layoffs, where TL denotes temporary layoffs. The model with exogenous firm exit assumes that the firm survival rate $(1 - G(z_{at})) = (1 - \delta)$ where $0 < \delta < 1$ is a parameter chosen to match the average firm survival rate in the data. The model without firm entry or exit has the same steady state as the benchmark model but N, N_E, and z_a remain fixed at their steady state values. The blue bars show the above-mentioned percentage-point differences between impulse responses in the benchmark model, the orange bars show the above-mentioned percentage-point differences between impulse responses in the model with exogenous firm exit, and the green bars show the above-mentioned percentage-point differences between impulse responses in the model with no firm entry or exit.