A Congestion Theory of Unemployment Fluctuations

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LAEF
Labor Markets and Macroeconomic Outcomes
Why is job creation so unattractive in recessions?

We propose a **congestion** theory of unemployment fluctuations, based on two facts:

1. in recessions, *more* unemployed find jobs
2. limited capacity of firms to absorb increases in unemployment by expanding hiring
   - Congestion: diminishing returns in new hires’ jobs (or convex hiring costs)

⇒ **Countercyclical congestion** (extra procyclicality of productivity in new jobs)

Provides a unified explanation for a range of macroeconomic patterns:

- strong amplification and propagation in the labor market
- relative cyclicality of new-hire wages *(alternative calibration target)*
- countercyclical labor wedge
- countercyclical earnings losses from job displacement and labor market entry
- ... all while featuring realistic insensitivity of hiring to policy changes such as UI
Outline

1. Empirical evidence
   - countercyclical shift of employment towards recently unemployed workers
   - congestion in hiring

2. Model structure
   - congestion mechanism
   - embed in a standard DMP model
   - calibrate to IRF of $u$ and/or new hires' relative wage cyclicality

3. Business cycle performance
   - volatility and comovement of labor market variables
   - estimate congestion unemployment

4. Three additional macroeconomic applications
   - labor wedge, earnings losses, sensitivity to policy changes
1. Empirical evidence

*Countercyclical hiring out of unemployment and congestion in hiring*
1. Employment share of workers with recent unemployment

CPS-ASEC (1976-2019): # of weeks workers spent in unemployment in previous year
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CPS-ASEC (1976-2019): # of weeks workers spent in unemployment in previous year
1. Flow origins of shifts in employment distribution

Unemployment-to-employment (UE) flows are strongly **countercyclical**
- see e.g. Burda and Wyplosz (1992), Fujita and Ramey (2009), Elsby et al. (2013)

CPS (1976-2019): quarterly average of monthly UE flows, log deviations from trend
1. Flow origins of shifts in employment distribution

Unemployment-to-employment (UE) flows are strongly **countercyclical**

- see e.g. Burda, Wyplosz (1992), Fujita, Ramey (2009), Elsby et al. (2013)

CPS (1976-2019): quarterly average of monthly UE flows, log deviations from trend
Why are UE flows countercyclical?

Use steady state expressions for unemployment, \( u = \frac{\delta}{\delta + f} \), and UE flows \( = f \cdot u \)

- \( \delta \): separation probability, \( f \): job finding probability

\[
\frac{d\text{UE}}{\text{UE}} = \frac{df}{f} + \frac{du}{u} \rightarrow \frac{d\text{UE}/\text{UE}}{du/u} = \frac{1}{(1 - u) \left[ -1 + \frac{d\delta/\delta}{df/f} \right]} + 1
\]

Relative cyclicity of \( \delta \) and \( f \) is key in explaining cyclicity of \( \text{UE} \):

- if \( \frac{d\delta/\delta}{df/f} = 0 \), then \( \frac{d\text{UE}/\text{UE}}{du/u} = -\frac{u}{1-u} \rightarrow \) UE flows are procyclical

- if \( \frac{d\delta/\delta}{df/f} < -\frac{u}{1-u} \), then \( \frac{d\text{UE}/\text{UE}}{du/u} > 0 \rightarrow \) UE flows are countercyclical
Cyclicality of job finding and separation probabilities

![Graph showing cyclicality of job finding and separation probabilities from 1980 to 2020. The x-axis represents years, and the y-axis represents log deviation from trend. The graph compares job finding rate (solid line) and separation rate (dashed line). The x-axis includes markers for 1980, 1990, 2000, 2010, and 2020.](image-url)
Cyclicality of job finding and separation probabilities

Job finding rate
Separation rate

Actual
Const. sep.
U rate
2. Limited capacity to absorb increases in unemployment by hiring

Congestion (in hiring): Firms’ limited capacity to absorb “pure” unemployment increases

- i.e. increases in unemployment that leave fundamentals (productivity) unchanged

Intuition from standard search model

- hiring depends on fundamentals (e.g. productivity), but market size is irrelevant
- rise in unemployed, with unchanged productivity, (immediately) hired away

Dynamics after “pure” increase in unemployment (consider one-time exogenous $\uparrow EU$):

- $u' = u - f(\bar{\theta})u + \uparrow EU$: no congestion ($v$ moves 1-to-1 with $u$, i.e. $\theta = v/u$ fixed)
- $u' = u - \overline{UE} + \uparrow EU$: full congestion (economy absorbs fixed $\overline{UE}$ at a time)
2. Response of labor market to “pure” unemployment increase

(a) \( \theta = \frac{v}{u} \) (and implicitly \( f \))

(b) \( u \)

(c) \( UE = f \cdot u \)

(d) \( v \)
2. Response of labor market to “pure” unemployment increase

Estimate VAR: \( y_t = [\ln ALP_t, \ln \delta_t, \ln \theta_t] \)

- \( ALP = \) average labor productivity, \( \delta = \) EU probability, \( \theta = \) labor market tightness
- Cholesky identification: response to \( \delta \) keeps \( ALP \) fixed upon impact
- IRF of labor market tightness \( \theta = v/u \) to separation rate shock:

![Graph of IRF of labor market tightness](attachment:image.png)
2. Model

Main idea
Main idea

Use standard Diamond-Mortensen-Pissarides (DMP) model, but
  ◦ incorporate diminishing returns to cohorts of new hires

Within this framework
  ◦ in recessions, UE flows increase (as separations increase) (empirical fact 1)
  → diminishing marginal product of new hires—our congestion mechanism!
  → discourages job creation (empirical fact 2)

Modeling choice for the mechanism:
Imperfect substitution b/w workers with different labor market experiences
  ◦ skill accumulation, career steps, internal labor markets, etc...
Main idea

Imperfect substitution between workers with different types of labor market experience

\[ Y = z \left( \sum_{k=1}^{K} \alpha_k n_k^\sigma \right)^{1/\sigma} \]

- \( z \): aggregate (total factor) productivity
- \( k \): particular type of labor market experience (e.g. job ladder, skill, ...)
- \( n_k \): # of workers of type \( k \)
- \( \alpha_k \): relative productivity
- \( \sigma \): guides diminishing returns (elasticity of substitution: \( \frac{1}{1-\sigma} \))
  - \( \sigma = 1 \): “no congestion” (standard) model
  - \( \sigma < 1 \): model featuring congestion in hiring
Main idea

Relative supply of worker types matters for productivity:

\[ p_k = \frac{\partial Y}{\partial n_k} = \alpha_k n_k^{\sigma - 1} \frac{Y}{\sum_{i=1}^{K} \alpha_i n_i^\sigma} \]

In recessions, when UE flows rise

→ recently unemployed become relatively abundant in employment (empirical fact 1)
→ depressed marginal product of new hires
→ discouraged job creation (empirical fact 2)

Countercyclical congestion reinterprets recessions: why does unemployment rise?

○ Standard question: Why do firms hire so little?
○ Our answer:
  Firms are actually (gross) hiring more—the jobs to be filled by the unemployed are already crowded.
2. Model

Details
Worker heterogeneity and congestion

Worker “types”

- $k \in \mathcal{K} = \{1, \ldots, K\}$: particular worker types
- employed workers move up one level each period: $k_{t+1} = k_t + 1$
- unemployed workers move down $k_u(k)$ levels each period: $k_{t+1} = k_t - k_u(k_t)$
  - $k_u(k) \in \{0, 1, \ldots, k - 1\}$ nests no-, full- and partial-downgrading

![Diagram showing worker types and transitions]

**Type upgrade**

employed workers move up one level each period: $k_{t+1} = k_t + 1$

**Type downgrading**

unemployed workers move down $k_u(k)$ levels each period: $k_{t+1} = k_t - k_u(k_t)$

- $k_u(k) \in \{0, 1, \ldots, k - 1\}$ nests no-, full- and partial-downgrading

**General case:**

Type downgrading by $k_u(k)$

**Specific case:**

Full type downgrading by $k_u(k) = k - 1$
Worker heterogeneity and congestion

Worker “types”

- \( k \in \mathcal{K} = \{1, \ldots, K\} \): particular worker types
- employed workers move up one level each period: \( k_{t+1} = k_t + 1 \)
- unemployed workers move down \( k_u(k) \) levels each period: \( k_{t+1} = k_t - k_u(k_t) \)
  - \( k_u(k) \in \{0, 1, \ldots, k - 1\} \) nests no-, full- and partial-downgrading

Congestion

- final good produced combining intermediate goods \((n_k)\): \( Y = z \left( \sum_{k=1}^{K} \alpha_k n_k^\sigma \right)^{1/\sigma} \)
- intermediate goods produced by “firms” using linear technology
- competitive market prices of intermediate goods: \( p_k = \frac{\partial Y}{\partial n_k} = \alpha_k n_k^{\sigma-1} \frac{Y}{\sum_{l=1}^{K} \alpha_l n_l^\sigma} \)

Everything that follows mirrors “standard” search model
Environment and timing

Environment

- workers hired by intermediate-goods firms in frictional labor market
  - random search, matches occur according to $M(u, v)$, $f(\theta) = M/u$ and $q(\theta) = M/v$
  - worker-firm matches separate with time-varying probability $\delta$
- final goods firm buys intermediate-inputs in perfectly competitive market
- wages are determined by period-by-period Nash bargaining, no wage rigidity
- free entry of intermediate-goods firms

Timing

- aggregate shocks: productivity and separation rate, $(z, \delta)$, materialize
- separated workers join unemployment pool, active matches produce
- employed upgrade, unemployed downgrade types and thereafter matching occurs
Worker and firm value functions

Value of employment and of unemployment for type-$k$ worker

$$W_{k,t} = w_{k,t} + \beta E_t \left[ (1 - \delta_{t+1}) W_{k+1,t+1} + \delta_{t+1} U_{k+1,t+1} \right] ,$$

$$U_{k,t} = b + \beta E_t \left[ f(\theta_t)(1 - \delta_{t+1}) W_{k-k_u(k),t+1} + (1 - f(\theta_t)(1 - \delta_{t+1})) U_{k-k_u(k),t+1} \right]$$

$w_{k,t}$: wage of type-$k$ worker, $b$: flow value of unemployment

Value of a job filled with type-$k$ worker and of unfilled job

$$J_{k,t} = p_{k,t} - w_{k,t} + \beta E_t \left[ (1 - \delta_{t+1}) J_{k+1,t+1} + \delta_{t+1} V_{t+1} \right] ,$$

$$V_t = -\kappa + q(\theta_t) \beta E_t \left[ (1 - \delta_{t+1}) \frac{u_{k,t}}{u_t} J_{k-k_u(k),t+1} + \delta_{t+1} V_{t+1} \right]$$

$\kappa$: flow cost of having an open vacancy
Productivity and size of hiring cohort

\[ p_1 \quad (\sigma = 0.241) \]

\[ ALP \quad (\sigma = 0.241) \]

\[ p_1 = ALP \quad (\sigma = 1) \]
Model mechanism and alternatives

Congestion occurs because recently unemployed become abundant in recessions

- fall in marginal product slows further hiring (despite free entry)
- depends on distribution of types in (un-)employment (and $\sigma$)

Alternative: what if not all new hires cause congestion?

- Extension in paper: only $1 - x$ cause congestion:

$$Y = z \left[ (1 - x) \left( \sum_{k=1}^{K} \alpha_k^c (n_k^c)^{\sigma} \right)^{1/\sigma} + x \left( \sum_{k=1}^{K} \alpha_k^{nc} n_k^{nc} \right) \right]$$

$\rightarrow$ isomorphic to our baseline, subject to “iso-congestion” reparameterization of $\sigma$

Alternative: what if hiring is slowed by increased costs?

- $\kappa(UE_t)' > 0$: gives similar amplification, but misses a range of other results
3. Business cycle performance

Sources of amplification and congestion unemployment
Parameterization

“Standard” features parametrized in “standard” fashion (Shimer, 2005)

- in particular, \( b \) s.t. replacement rate of 40 percent (i.e. high fundamental surplus)

Worker heterogeneity

- \( K = 160 \): absorbing “max type” until separation
- \( k_u(k) = k - 1 \): full downgrading (but recall robustness w.r.t. no-congestion hires)
- \( \alpha_k \): s.t. \( p_k = p = 1 \) for all \( k \) (all types have same surplus in steady state)

Aggregate shocks

- \( z \) and \( \delta \): target volatility and persistence of \( ALP \) and \( UE/E \) in data
  - \( UE/E \) crucial for congestion mechanism
  - Robustness in paper: match \( \delta \) directly

Congestion parameter \( \sigma \)

- match limited capacity to absorb unemployed (IRF of \( \theta \) w.r.t. \( \delta \))
- Robustness/validation: new hires’ wage cyclicality
Parameterizing $\sigma$: IRF of $\theta$ w.r.t $\delta$
Parametrizing $\sigma$: Congestion and amplification
Parameterizing $\sigma$: Excess cyclicality of new-hire wages
# Model performance: Business cycle statistics

<table>
<thead>
<tr>
<th></th>
<th>ALP</th>
<th>f</th>
<th>δ</th>
<th>u</th>
<th>v</th>
<th>θ</th>
<th>UE/E</th>
<th>MPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>s.d.(x)</td>
<td>0.010</td>
<td>0.053</td>
<td>0.067</td>
<td>0.104</td>
<td>0.127</td>
<td>0.229</td>
<td>0.067</td>
<td>NA</td>
</tr>
<tr>
<td>corr(u, x)</td>
<td>−0.11</td>
<td>−0.93</td>
<td>0.85</td>
<td>1</td>
<td>−0.94</td>
<td>−0.98</td>
<td>0.83</td>
<td>NA</td>
</tr>
</tbody>
</table>

| baseline model (σ = 0.241) |     |    |    |     |     |     |      |     |
| s.d.(x)    | 0.010 | 0.059 | 0.122 | 0.121 | 0.102 | 0.207 | 0.067 | 0.055 |
| corr(u, x) | −0.46 | −0.92 | 0.74  | 1     | −0.72 | −0.94 | 0.87  | −0.86 |

| standard model (σ = 1) without separation shocks |     |    |    |     |     |     |      |     |
| s.d.(x)    | 0.010 | 0.005 | 0.000 | 0.004 | 0.014 | 0.016 | 0.003 | 0.010 |
| corr(u, x) | −0.65 | −0.65 | 0.00  | 1     | −0.49 | −0.65 | −0.27 | −0.65 |

| standard model (σ = 1) with separation shocks |     |    |    |     |     |     |      |     |
| s.d.(x)    | 0.010 | 0.005 | 0.073 | 0.055 | 0.046 | 0.017 | 0.054 | 0.010 |
| corr(u, x) | −0.50 | −0.62 | 0.91  | 1     | 0.96  | −0.62 | 0.70  | −0.50 |
Model performance: Beveridge curve

![Beveridge curve diagram]

- Data
- No-congestion ($\sigma = 1$)
- Congestion ($\sigma = 0.241$)
Sources of amplification

Surplus relevant for hiring in “standard” model ($S$) and in congestion model ($S_1$)

$$S_t = z_t - b + \beta \mathbb{E}_t (1 - \delta_{t+1})(1 - f(\theta_t)\phi)S_{t+1}$$

$$S_{1,t} = p_{1,t} - b + \beta \mathbb{E}_t [(1 - \delta_{t+1})(S_{2,t+1} - f(\theta_t)\phi S_{1,t+1})]$$

Differences between standard and our congestion model

- **Flow productivity channel**: $sd(p_1) > sd(z)$
- **Cohort channels**: continuation values have different dynamics
  - continuing in employment entails upgrading to $S_{2,t+1}$
  - falling into unemployment entails downgrading to $S_{1,t+1}$
Sources of amplification: Flow productivity channel

Use data on ALP and UE/E to construct $p_1$
Sources of amplification: Cohort channels

IRFs of employment distributions to a one-time positive $\delta$ shock

![Graph showing Employment, $e_k$ and Marginal product, $p_k$]
**Sources of amplification: Quantification**

\[
S_{1,t} = p_{1,t} - b + \beta \mathbb{E}_t [(1 - \delta_{t+1}) S_{2,t+1} - f(\theta_t)(1 - \delta_{t+1}) \phi S_{1,t+1}]
\]

\[
S_{1,t} = z_t - b + \beta \mathbb{E}_t [(1 - \delta_{t+1})(1 - f(\theta_t^*) \phi) S_{t+1}^*) + S_t^* - S_{t+1}^*]
\]

(i) No-congestion model surplus

\[
+ \beta \mathbb{E}_t [(1 - \delta_{t+1})(1 - f(\theta_t) \phi)(S_{2,t+1} - S_{t+1}^*)]
\]

(ii) Flow productivity channel

\[
+ \beta \mathbb{E}_t [(1 - \delta_{t+1}) f(\theta_t) \phi (S_{2,t+1} - S_{1,t+1})]
\]

(iii) Present value channel (cohort effect of “upgrading”)

\[
+ \beta \mathbb{E}_t [(1 - \delta_{t+1}) f(\theta_t) \phi (S_{2,t+1} - S_{1,t+1})]
\]

(iv) Outside option channel (cohort effect of “downgrading”)

\[
S_{st}^* = z_t - b + \beta \mathbb{E}_t [(1 - \delta_{t+1})(1 - f(\theta_{st}) \phi) S_{t+1}^*)] \quad \text{&} \quad \theta_{st}^*: \text{no-congestion surplus} \quad \text{&} \quad \theta_t
\]

\[
S_t^* = p_{1,t} - b + \beta \mathbb{E}_t [(1 - \delta_{t+1})(1 - f(\theta_t) \phi) S_{t+1}^*)]: \text{match surplus with } p_{1,t}
\]
Sources of amplification: Quantification

Variation in counterfactual labor market tightness ($\tilde{\theta}$) driven by

- (i) no-congestion model surplus
- (ii) flow productivity channel
- (iii) present value channel
- (iv) outside option channel

<table>
<thead>
<tr>
<th>Source of Amplification</th>
<th>Standard Deviation</th>
<th>Contribution to Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-congestion model</td>
<td>0.019</td>
<td>0.049</td>
</tr>
<tr>
<td>+ Flow productivity channel</td>
<td>0.052</td>
<td>0.162</td>
</tr>
<tr>
<td>+ Present value channel</td>
<td>0.178</td>
<td>0.851</td>
</tr>
<tr>
<td>+ Outside option channel</td>
<td>0.207</td>
<td>1</td>
</tr>
</tbody>
</table>
Congestion unemployment: Historical decomposition

\[ p_1 \quad (\sigma = 0.241) \]
\[ ALP \quad (\sigma = 0.241) \]
\[ p_1 = ALP \quad (\sigma = 1) \]
Congestion unemployment: Historical decomposition

Unemployment fluctuations driven solely by congestion: congestion unemployment

\[ S_{k,t}^c = p_{k,t} \cdot \frac{\bar{z}}{z_t} - b + \beta \mathbb{E}_t(1 - \delta)S_{k+1,t+1}^c - \beta \mathbb{E}_t(1 - \delta)f(\theta_t^c)\phi S_{1,t+1}^c \forall k. \]

- \( S_k^c \): surplus variation only due to congestion

\[ \kappa = q(\theta_t^c)\beta \mathbb{E}_t(1 - \delta)S_{1,t}^c \]

- \( \theta^c \): variation in labor market tightness only due to congestion

\[ u_{t+1}^c = (1 - f(\theta_t^c))u_t^c + \bar{\delta}(1 - u_t^c) \]

- \( u^c \): congestion unemployment
Congestion unemployment: Historical decomposition

Use data on ALP and UE/E to estimate time-path of entire model (Kalman filter)
4. Additional applications

Congestion and three macroeconomic regularities
Macroeconomic implications of congestion

1. Business cycle accounting: the labor wedge
   - countercyclical in the data and attributed to “household side”

2. Costs of entering labor market and of displacement
   - large and countercyclical in the data

3. Sensitivity to labor market policies
   - relatively low, hard to square with high labor market volatility
1. The labor wedge

The labor wedge is defined as $MPL_t(1 - \tau_t) = MRS_t$

- estimates in data show a cyclical labor wedge
  - see e.g. Hall (1997), Chari, Kehoe, McGrattan (2007), Shimer (2009)
- moreover, fluctuations in labor wedge assigned mainly to “household” (MRS) side
  - should focus on how MRS deviates from real wage (e.g. Karabarbounis, 2014)

Extend our baseline model to include capital ($\tilde{K}$):

$$Y = z\tilde{K}^a \left( \sum_{k=1}^{K} \alpha_k \eta_k^\sigma \right)^{\frac{1}{\sigma}}$$

- considering the (spot) productivity of new hires $p_1$ only

$$p_1 = (1 - a)\frac{Y}{N} \quad \frac{\alpha_1 s_1^{\sigma-1}}{\sum_{k=1}^{K} \alpha_k s_k^\sigma} = MRS$$

allocative/new hires’ MPL  
standard MPL  
labor wedge (congestion term)
1. The labor wedge: Congestion as a resolution?
2. Countercyclical costs of job displacement and labor market entry

Large and persistent

... earnings losses from graduating in recessions (e.g. Kahn, 2010, Schwandt and von Wachter, 2019)

◦ graduation costs: skill mismatch, employer quality (e.g. Oreopoulos et al., 2012)

... and countercyclical displacement costs (e.g. Davis and von Wachter, 2011)

◦ driven by wage drops, employer “quality” (e.g. Schmieder et al., 2019)

*Level* of costs explained through various theories

◦ displacement costs: fall off a job ladder (e.g. Jarosch, 2015, Jung and Kuhn, 2018)

Our model speaks to the cyclicality of these costs

◦ not well understood in existing literature
2. Costs of displacement

Davis and von Wachter (2011): earnings losses in recessions relative to booms
2. Costs of labor market entry

Schwandt and von Wachter (2019): earnings losses of new hires and unemployment

![Graph showing the effect of unemployment rate on log earnings, $\beta_e$, with Data and Congestion ($\sigma = 0.241$) lines.](image)
2. Costs of displacement and labor market entry

Our model offers a basic explanation

- relatively large cohorts of new hires are abundant in employment
  - pushes down their wages (reflecting marginal products)
  - cohort effects make these initial conditions long-lasting

The above mechanism is broadly consistent with the available evidence

- earnings losses linked to persistent wage declines
- driven primarily by a shift towards jobs of “lower quality”
3. Sensitivity to labor market policies

Costain and Reiter (2008): search models have a hard time

- simultaneously matching labor market volatility
- ... and sensitivity of the labor market to changes in policies
- estimate long-run elasticity of $u$ w.r.t. $b$ of $\epsilon_{u,b} \in (2, 3.5)$

In our model, labor market volatility is not generated by low fundamental surplus

- instead, countercyclical congestion makes labor market variables volatile
- implied long-run elasticity of $u$ w.r.t. $b$ of $\epsilon_{u,b} \approx 2.6$
Conclusion
Conclusion: A congestion theory of unemployment fluctuations

Two key empirical facts

1. employment shifts towards recently unemployed in downturns
2. unemployment increases not absorbed quickly, even with unchanged fundamentals

We propose a model consistent with the above facts

- worker types are imperfect substitutes
- abundant types see their marginal productivity fall, discouraging their hiring
- congestion is a strong amplification mechanism

Our baseline model sheds new light on a range of macroeconomic patterns

- labor market variables over the business cycle
- relative wage cyclicality of new hires
- countercyclical labor wedge
- countercyclical costs of displacement and labor market entry
- low sensitivity of labor market variables to labor market policies
Thanks
UE flows: observed and counterfactual (constant separations)

-30 -20 -10 0 10 20 30
UE rate, log deviation from trend

-10 0 10 20 30
UE flows, log deviation from trend

Actual Const. sep. U rate
Response of labor markets to “pure” unemployment increase

Data
No-congestion ($\sigma = 1$)
Congestion ($\sigma = 0.241$)
Worker type and (un-)employment evolution

Laws of motion for (un-)employment

\[ u_{k-k_u(k),t} = (1 - f(\theta_{t-1}))u_{k,t-1} + \delta_t e_{k-k_u(k),t} \quad \text{for} \; k \in \mathcal{K} \]

\[ e_{k-k_u(k),t} = (1 - \delta_{t-1})e_{k-k_u(k)-1,t-1} + f(\theta_{t-1})u_{k,t-1} \quad \text{for} \; k \in \mathcal{K} \]
Iso-congestion model

- Iso-congestion curve $\sigma(x)$ (left axis)
- Congestion along $\sigma(x)$, model-data RMSE$\theta$ (right axis)
- SD($u$) along $\sigma(x)$ (right axis)

Share of no-congestion workers, $x$
# Full set of parameter values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target/Source</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Congestion</strong></td>
<td><strong>No congestion</strong></td>
<td></td>
</tr>
<tr>
<td>$\beta$  Discount factor</td>
<td>0.99</td>
<td>Annual interest rate</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>$\mu$ Matching elasticity</td>
<td>0.72</td>
<td>Shimer (2005)</td>
<td>0.72</td>
<td>0.72</td>
</tr>
<tr>
<td>$\overline{m}$ Matching efficiency</td>
<td>0.57</td>
<td>Job finding probability</td>
<td>0.57</td>
<td>0.57</td>
</tr>
<tr>
<td>$\eta$ Bargaining power</td>
<td>0.72</td>
<td>Hosios condition</td>
<td>0.72</td>
<td>0.72</td>
</tr>
<tr>
<td>$b$ Unemployment flow value</td>
<td>0.39</td>
<td>Avg. replacement rate</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>$\kappa$ Vacancy posting cost</td>
<td>0.21</td>
<td>Normalization</td>
<td>—</td>
<td>1.00</td>
</tr>
<tr>
<td>$\bar{z}$ Productivity shock, mean</td>
<td>1</td>
<td>Normalization</td>
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<td>$\sigma_z$ Productivity shock, st. dev.</td>
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<td>$\rho_{\delta,z}$ Correlation of shocks to $z$ and $\delta$</td>
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<td>$-0.560$</td>
<td>corr($ALP, \delta$)</td>
<td>$-0.41$</td>
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<tr>
<td>$\sigma$ Elasticity of substitution b/w workers</td>
<td>0.241</td>
<td>1</td>
<td>Impulse response of $\theta$ to $\delta$, see IRF Figure</td>
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<tr>
<td>$\alpha_k$ Relative productivities of worker types</td>
<td>see Appendix</td>
<td>$\rho_k = 1$ for all $k$</td>
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$\zeta = \frac{1}{\theta} = 1 - 0.00$ Normalization

$\sigma = 0.241$ Impulse response of $\theta$ to $\delta$, see IRF Figure

$\rho_k = 1$ for all $k$
Model Performance: Full business cycle statistics

### Panel A: Data

<table>
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<tr>
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<th>ALP</th>
<th>f</th>
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<th>v</th>
<th>θ</th>
<th>UE/E</th>
<th>p1</th>
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**Correlation matrix**

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### Panel B: Congestion Model

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**Correlation matrix**

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Model Performance: Full business cycle statistics

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