JOBS AND MATCHES:
QUITs, REPLACEMENT HIRING, AND VACANCY CHAINS

Yusuf Mercan
U Melbourne

Benjamin Schoefer
UC Berkeley

June 2019
**Job Openings**

Key variable for aggregate labor market behavior.

**Data**
- Drives the job finding rate of unemployed workers,
- And thereby employment fluctuations.

**Theory** Diamond-Mortensen-Pissarides (DMP) search model.
- Job openings = creation of **new** jobs.
- Driven solely by “fundamentals” in costs and benefits of hiring: productivity, discount factor, wages, separations, ...
This Paper

I Establish/point out three empirical facts:

1. Job: \( \sim 60\% \) of job openings aim to fill old jobs vacated by quits.
2. Establishment: 1 quit \( \Rightarrow \sim 1 \) new hire.
3. Aggregate: Hires tightly track quits.

II Extend textbook DMP model to accommodate old jobs and quit-replacement hiring.

- Sunk job creation cost \( \Rightarrow \) Vacant positions are valuable.
- On-the-job search \( \Rightarrow \) Job-to-job quits drive vacancy repostings.

\( \Rightarrow \) Two types of jobs: new standard DMP entry

\( \underline{\text{old}} \) vacated by quits and reposted

III Quantitatively study aggregate implications:

- Vacancy chains & “multipliers”.
- Business cycles amplification.
Road Map

Mechanism

Empirical Evidence

Model

Quantitative Analysis

Business Cycle Implications
Two-Period DMP

- New hires:
  \[ h = q(\theta) \times v \]
  - New hires \( h \) is equal to the product of the job filling rate \( q(\theta) \) and the number of job openings \( v \).

- Zero-profit condition for vacancy posting:
  \[ \kappa = q(\theta) \beta (y - w) \]
  - The flow cost \( \kappa \) is equal to the product of the job filling rate \( q(\theta) \), the efficiency wage parameter \( \beta \), and the difference between the wage \( y \) and the wage rate \( w \), which represents the returns to hiring.

where market tightness \( \theta \) is defined as:
\[ \theta = \frac{\text{Job Openings}}{\text{Unemployed Searchers}} \]

- Equilibrium \( \theta \) through:
  - Congestion in labor market: \( q'(\theta) < 0 \).
  - Wage bargaining: \( w_y, w_\theta > 0 \).

- A model solely of new job creation:
  - Linear production function (CRS).
  - No sunk investments.
New jobs: pay one-time fixed cost of job creation $k(n)$ (Fujita and Ramey (2007)):

$$\kappa + k(n) = q(\theta) \beta(y - w)$$

Old jobs: costs are sunk and vacancies have strictly positive equilibrium value:

$$\kappa < q(\theta) \beta(y - w)$$

⇒ Old jobs are reposted.
⇒ Quits trigger replacement hiring.
⇒ Quits can act as a (proximate) driver of total job openings in “vacancy chain”.
Conventional View of Quits in DMP

Add on-the-job-search to the baseline model:

$$\theta = \frac{\text{Job Openings}}{\text{Total Searchers}} = \frac{\text{Job Openings}}{\text{Unemployed} + \text{On-the-job Searchers}}$$

$$\kappa = q(\theta) \beta [(y - w) + (1 - P(\text{Quit})) \cdot \beta(y - w)]$$

○ Two market-level effects of quits:

  ⚫ Labor supply channel: $q(\theta) \uparrow$
  ☹ Match duration channel: $[1 - \text{Prob}(\text{Quit})] \downarrow$

○ But: jobs vacated by quits are not reposted!

  ○ ... zero value of vacancy, old or new.
  ○ Match resolution and job destruction similar events.
Road Map

Mechanism

Empirical Evidence

Model

Quantitative Analysis

Business Cycle Implications
What is a Job Opening?

Job Openings and Labor Turnover Survey (JOLTS) definition:

[...] all positions that are open (not filled) on the last business day of the month. A job is “open” only if it meets **all three** of the following conditions:

1. A specific **position exists** and there is **work available** for that position.
2. The **job could start within 30 days**.
3. There is **active recruiting** for workers from outside the establishment.

⇒ Notion of **sunk** cost!
Empirical Evidence

Four levels of evidence:

1. *Vacancy survey*
2. Establishment level worker flows
3. Local labor markets
4. Aggregate comovements
Vacancy Level Evidence

- German IAB Vacancy Survey.
- Annual, 2000-2015, ~ 75,000 establishments per year.
- Detailed questions on the last filled opening in the past 12 months.

"Why did you post this particular job opening?"

<table>
<thead>
<tr>
<th>Replacement Hiring</th>
<th>Demand Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary</td>
<td>Long-term</td>
</tr>
<tr>
<td>8.7%</td>
<td>47.4%</td>
</tr>
<tr>
<td>56.1%</td>
<td></td>
</tr>
</tbody>
</table>
Composition of Job Openings

~ 50% – 60% of job openings to replace workers.
Empirical Evidence

Four levels of evidence:

1. Vacancy survey
2. Establishment level worker flows
3. Local labor markets
4. Aggregate comovements
Establishment-Level Evidence

Run regression at the establishment level:

\[
\frac{\text{Hires}_{e,t}}{\text{Emp}_{e,t-1}} = \beta_0 + \beta_1 \frac{\text{Quits}_{e,t}}{\text{Emp}_{e,t-1}} + \gamma X_{e,t} + \alpha_e + \alpha_t + \varepsilon_{e,t}
\]

Source: IAB Establishment Survey (“annual German JOLTS”).
Establishment-Level Quits and Hires
Establishment-Level Quits and Job Openings
## Establishment Level Regressions

### A. Dependent Variable: $\frac{\text{New Hires}_{et}}{\text{Emp.}_{et-1}}$

<table>
<thead>
<tr>
<th>Quits$_{et}$</th>
<th>All</th>
<th>Positive Quits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emp$_{et-1}$</td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>.736</td>
<td>.727</td>
</tr>
<tr>
<td></td>
<td>(.067)</td>
<td>(.068)</td>
</tr>
</tbody>
</table>

| Establishment FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ |
| Year x Industry FE | ✓ | ✓ |
| Year x State FE | ✓ | ✓ |
| N | 24509 | 24509 | 24509 | 18015 | 18015 | 18015 |
| R² | .64 | .64 | .64 | .66 | .67 | .67 |

### B. Dependent Variable: $\frac{\text{Job Openings}_{et}}{\text{Emp.}_{et-1}}$

<table>
<thead>
<tr>
<th>Quits$_{et}$</th>
<th>All</th>
<th>Positive Quits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emp$_{et-1}$</td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>.048</td>
<td>.046</td>
</tr>
<tr>
<td></td>
<td>(.026)</td>
<td>(.027)</td>
</tr>
</tbody>
</table>

| Establishment FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ |
| Year x Industry FE | ✓ | ✓ |
| Year x State FE | ✓ | ✓ |
| N | 23209 | 23209 | 23209 | 16964 | 16964 | 16964 |
| R² | .37 | .37 | .37 | .35 | .36 | .35 |
# Event Study

<table>
<thead>
<tr>
<th>Lead/Lag</th>
<th>All</th>
<th>Positive Quits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-1</td>
<td></td>
<td>.051</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.057)</td>
</tr>
<tr>
<td>0</td>
<td>.736</td>
<td>.753</td>
</tr>
<tr>
<td></td>
<td>(.067)</td>
<td>(.068)</td>
</tr>
<tr>
<td>+1</td>
<td></td>
<td>.050</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.069)</td>
</tr>
<tr>
<td>+2</td>
<td>.086</td>
<td>.086</td>
</tr>
<tr>
<td></td>
<td>(.085)</td>
<td>(.088)</td>
</tr>
<tr>
<td>+3</td>
<td></td>
<td>.161</td>
</tr>
<tr>
<td>Establishment FE</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Year FE</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>N</td>
<td>24509</td>
<td>11414</td>
</tr>
<tr>
<td>R²</td>
<td>.64</td>
<td>.67</td>
</tr>
</tbody>
</table>
Empirical Evidence

Four levels of evidence:

1. Vacancy survey
2. Establishment level worker flows
3. Local labor markets
4. Aggregate comovements
Local-Labor-Market-Level Quits and Hires

![Graph showing the relationship between rate of quits and hires and log of unemployed population.](image-url)
Local-Labor-Market-Level Quits and Job Openings

[Graph showing the relationship between the rate of quits and job openings, with the x-axis representing the log of the number of unemployed and the y-axis representing the rate per 100 workers. The graph includes data points for both quit rates and job opening rates.]

Quit Rate
Job Opening Rate
Empirical Evidence

Four levels of evidence:

1. Vacancy survey
2. Establishment level worker flows
3. Local labor markets
4. Aggregate comovements
Quits and Hires (Quarterly Rate per 100 Workers)
**Quits and Job Openings** (Quarterly Rate per 100 Workers)

![Graph showing Quit and Job Openings trends](image-url)
Summary of Empirical Evidence

Old rather than new jobs behind job openings:

- **Vacancy** level: \( \sim 60\% \) of job openings to replace quitting workers.

Suggests quit-replacement hiring:

- **Establishment** level: 1 quit \( \propto 0.7-0.8 \) new hires.
- **Aggregate** level: Strongly procyclical quits, hires and vacancies.

Interpretation:

- ✓ Quit-replacement hiring: concentrated in **same firm/job**!
- X Standard view: market level.
Road Map

Mechanism
Empirical Evidence
Model
Quantitative Analysis
Business Cycle Implications
ENVIRONMENT

○ Equilibrium search model — TEXTBOOK DMP
  + fixed cost of vacancy creation
  + on-the-job search.

○ Random search under CRS matching function.
  ○ On-the-job search with relative efficiency $\lambda$.

○ Different types of exogenous shocks:
  $\sigma$: match separation
    ○ Firm can repost vacated job with probability $\gamma$.
  $\delta$: job destruction
    ○ Permanent destruction $\Rightarrow$ No reposting.
QUITS AND ON THE JOB SEARCH: \( \text{Pr}(\text{Quit}) = \lambda f(\theta) \)
Worker Problem

Unemployed:

\[ U(s) = b + \beta \left[ (1 - \delta)(1 - \sigma)f(\theta)\mathbb{E}[W(s')] + (1 - (1 - \delta)(1 - \sigma)f(\theta))\mathbb{E}[U(s')] \right] \]

Employed:

\[ W(s) = w(s) + \beta (\delta + (1 - \delta)\sigma)\mathbb{E}[U(s')] + \beta (1 - \delta)(1 - \sigma) \left[ \lambda f(\theta) + (1 - \lambda f(\theta)) \right] \mathbb{E}[W(s')] \]

Unemployment LoM:

\[ u_t = \left[ (1 - (1 - \delta)(1 - \sigma)f(\theta_{t-1}) \right] u_{t-1} + \delta(1 - u_{t-1}) + (1 - \delta)\sigma(1 - u_{t-1}) \]

\( \text{stay unemployed} \qquad \text{EU: job destruction} \qquad \text{EU: match separation} \)
Firm Problem

Vacant job:

\[ V(s) = -\kappa + \beta (1 - \delta) \left[ q(\theta)(1 - \sigma)E[J(s')] + (1 - q(\theta)(1 - \sigma))E[V(s')] \right] \]

Filled job:

\[ J(s) = y - w(s) + \beta (1 - \delta) \left[ \gamma (\sigma + (1 - \sigma)\lambda f(\theta))E[V(s')] + (1 - \sigma)(1 - \lambda f(\theta))E[J(s')] \right] \]

New job creation:

\[ N(s) = -k(n) + V(s) \]

Free Entry implies \( N(s) = 0 \):

\[ V(s) = k(n) \]
Vacancy Dynamics

In equilibrium vacancies have positive value.

⇒ Firms will repost positions.
⇒ Vacancies become predetermined (not jump variable anymore!).

\[ v_t = n_t + (1 - \delta) \left( 1 - (1 - \sigma)q(\theta_{t-1}) \right) v_{t-1} \]

Inflow of “old jobs”

\[ + \gamma \left( (1 - \sigma)\lambda f(\theta_{t-1}) e_{t-1} + \sigma e_{t-1} \right) \]

repoted: EE

repoted: EU
Set of worker and firm value functions, wage function and new job creation such that:

- $W(s), U(s), J(s), V(s)$ satisfy worker and firm Bellman Equations.
- Wage function $w(s)$ solves the Nash Bargaining problem.
- Unemployment $u$ and vacancies $v$ satisfy the LoMs induced by Bellman Equations.
- New job creation $n$ solves firm free-entry condition.
Road Map

Mechanism

Empirical Evidence

Model

Quantitative Analysis

Business Cycle Implications
CALIBRATION

Set model period to a month.

Matching function: \( M(S, V) = \mu S^{\eta} V^{1-\eta} \), where \( S = u + \lambda e \).

<table>
<thead>
<tr>
<th>A. PREDETERMINED</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor</td>
<td>( \beta )</td>
</tr>
<tr>
<td>Worker bargaining share</td>
<td>( \phi )</td>
</tr>
<tr>
<td>Elasticity of matching function</td>
<td>( \eta )</td>
</tr>
<tr>
<td>Unemployment benefit</td>
<td>( b )</td>
</tr>
<tr>
<td>Reposting rate</td>
<td>( \gamma )</td>
</tr>
<tr>
<td>Vacancy creation cost</td>
<td>( k_1 )</td>
</tr>
<tr>
<td></td>
<td>( k_2 )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. ESTIMATED</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative efficiency of OJS</td>
<td>( \lambda )</td>
</tr>
<tr>
<td>Scale of matching function</td>
<td>( \mu )</td>
</tr>
<tr>
<td>Job destruction</td>
<td>( \delta )</td>
</tr>
<tr>
<td>Match separation</td>
<td>( \sigma )</td>
</tr>
<tr>
<td>Vacancy posting cost</td>
<td>( \kappa )</td>
</tr>
</tbody>
</table>
## Targets and Model Fit

<table>
<thead>
<tr>
<th>Target</th>
<th>Data</th>
<th>Model</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unemployment rate</td>
<td>0.057</td>
<td>0.057</td>
<td>CPS - Shimer (2005)</td>
</tr>
<tr>
<td>Job-to-job rate</td>
<td>0.025</td>
<td>0.025</td>
<td>CPS - Fujita and Nakajima (2016)</td>
</tr>
<tr>
<td>Unemployed job finding rate</td>
<td>0.45</td>
<td>0.45</td>
<td>CPS - Shimer (2005)</td>
</tr>
<tr>
<td>Reposted vacancy share</td>
<td>0.56</td>
<td>0.56</td>
<td>IAB German Job Vacancy Survey</td>
</tr>
<tr>
<td>Job filling rate</td>
<td>0.9</td>
<td>0.9</td>
<td>Fujita and Ramey (2007)</td>
</tr>
</tbody>
</table>
**Micro Vacancy Chains**

Chain: Expected count of vacancies “generated” by one vacancy.

Define \( \Upsilon := \frac{u}{u + \lambda (1-u)} \).

1. Special case: \( \delta = 0, \gamma = 1 \):

\[
\mathbb{E}[C] = \sum_{c=1}^{\infty} c(1 - \Upsilon)^{c-1} \Upsilon = \frac{1}{\Upsilon} = \frac{u + \lambda (1 - u)}{u}
\]

\( u \uparrow \Rightarrow \mathbb{E}[C] \downarrow \)

\( \lambda \uparrow \Rightarrow \mathbb{E}[C] \uparrow \)

2. Gross vacancy chain: \( \delta > 0, \gamma < 1 \):

\[
\mathbb{E}[C] = \frac{\delta + (1 - \delta)q(\Upsilon + \gamma(1 - \Upsilon))}{1 - (1 - \delta)(1 - q\Upsilon)} \approx 1.88
\]

Tractable, DMP, equilibrium version of vacancy chain in Akerlof, Rose and Yellen (1988)!
Towards Aggregate Equilibrium Effects...

\[v_t = n_t + (1 - \delta)\left(\left(1 - (1 - \sigma)q(\theta_{t-1})\right)v_{t-1} + \gamma(1 - \sigma)\lambda f(\theta_{t-1})e_{t-1} + \sigma e_{t-1}\right)\]  
\[+ \varepsilon_{\tilde{v}}\]

\[\tilde{v}_t: \text{inherited vacancies}\]

Aggregate effects of vacancy chain depend on “crowd-out” from new job creation:

\[\frac{dn}{d\tilde{v}} \in [-1, 0]\]

3. Net vacancy chain:

\[\mathbb{E}[C^{\text{net}}] = \frac{\delta + (1 - \delta)q(\Upsilon + \gamma(1 - \Upsilon)(1 + \frac{dn}{d\tilde{v}}))}{1 - (1 - \delta)(1 - q\Upsilon)}\]

Full crowd-out: \[\frac{dn}{d\tilde{v}} = -1 \Rightarrow \mathbb{E}[C^{\text{net}}] = 1\]
Empirical (Short-run) Crowd-Out

- Moretti, Thulin (2013)
- Weinstein (2018)
- Gathmann et al. (2018)
- Cerqua, Pellegrini (2018)
- Jofre-Monseny et al. (2016)
- Mian, Sufi (2014)
- Cahuc et al. (2017, firms)
- Giupponi, Landais (2018)
- Marchand (2012)
- Acemoglu et al. (2016)
- Black et al. (2005)
- Cahuc et al. (2017, jobs)
- Zou (2017)
- Jofre-Monseny et al. (2016)
- Moretti (2010)
- Black et al. (2005)
- Marchand (2012)
- Giupponi, Landais (2018)
- Jofre-Monseny et al. (2018)
- de Blasio, Menon (2011)
- Ciccone et al. (2011)
- Cahuc et al. (2017, firms)
- Mian, Sufi (2014)
- Moretti (2010)
- Jofre-Monseny et al. (2016)
- Acemoglu et al. (2016)
- Black et al. (2005)
- Giupponi, Landais (2018)
- Jofre-Monseny et al. (2018)
- de Blasio, Menon (2011)

- Full Crowd-Out
  - Standard DMP ($k_2=0$)
- No Crowd-Out
  - ($k_2=\infty$)

- $d\text{Emp}_{\text{Spillover}} / d\text{Emp}_{\text{Direct}}$
Job Creation Costs: \( k(n) = k_1 + k_2 \frac{(n-\bar{n})}{\bar{n}} \)

Free-entry condition under:

1. No creation cost \((k_1 = 0, k_2 = 0)\):
   \[
   0 = V
   \]

2. Fixed marginal cost \((k_1 > 0, k_2 = 0)\):
   \[
   k_1 = V
   \]

3. Linear marginal cost \((k_1 > 0, k_2 > 0)\):
   \[
   k_1 + k_2 \frac{(n-\bar{n})}{\bar{n}} = V
   \]
Net Effects of Reposting

Our calibration

Standard DMP
**Equilibrium Vacancy “Multiplier”**

\[
v_t = n_t + (1 - \delta) \left( (1 - (1 - \sigma)q(\theta_{t-1}))v_{t-1} + \gamma \left( (1 - \sigma)\lambda f(\theta_{t-1})e_{t-1} + \sigma e_{t-1} \right) \right) + \varepsilon_{t}\]

... in response to one-time transitory shock to vacancy stock:

\[
M(h) := \frac{\sum_{s=1}^{h} dv_s}{\varepsilon_{1}}
\]
Other Outcomes

New Job Creation

Vacancy Stock

Unemployment
Roadmap

Mechanism

Empirical Evidence

Model

Quantitative Analysis

Business Cycle Implications
EXPERIMENTS

○ One-time, unanticipated aggregate shock to
  ○ labor productivity $y$
  ○ on-the-job search intensity $\lambda$
  ○ matching efficiency $\mu$.

○ Compare IRFs of three economies.

**GREEN**: Vacancy reposting — full equilibrium dynamics.

**BLUE**: No incremental reposting — keep repostings at SS.

**RED**: Full crowd-out — new and old jobs are perfect substitutes.

$$v_t = n_t + (1 - \delta) \left( (1 - (1 - \sigma)q(\theta_{t-1}))v_{t-1} \right)$$

Inflow of “old jobs”

$$\gamma \left( (1 - \sigma)\lambda f(\theta_{ss})e_{ss} + \sigma e_{ss} \right)$$

- reposted: EE
- reposted: EU
Cyclical Amplification: Aggregate Productivity Shock
Does the Vacancy Chain Amplify Business Cycles?

Mechanism in model:

\[ y \uparrow \Rightarrow \text{Returns to hiring} \uparrow \Rightarrow n \uparrow \Rightarrow v, \theta \uparrow \]

\[ \Rightarrow \text{Job finding rate, Quits} \uparrow \xrightarrow{k_2>0} v \uparrow \]

Total vacancies increase by more than in model without reposting!
AGGREGATE PRODUCTIVITY SHOCK

New Job Creation

Vacancy Stock

Unemployment

- Reposting
- No Reposting
- Full Crowd-Out, $k(t, \text{Inflow})$
Other Shocks
Matching Efficiency Shock

New Job Creation

Vacancy Stock

Unemployment
Conclusion

- Tension:
  - DMP model: all job openings are for new jobs.
  - Data: ~60% of job openings are for old jobs, vacated by a quit.

- Fix: sunk vacancy creation cost for new jobs generates quit-replacement hiring.

- Rich notion of vacancy chain and vacancy multiplier.

- Aggregate effects depend on crowd-out between new and old jobs.
  - Evidence suggests very limited short-run crowd-out.

- One implication: procyclicality of quits may be a key (proximate) contributor to fluctuations in job openings.