Vacancies and hiring through different recruiting channels

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Motivation

- How tight is the labor market?
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- To answer, need to
  1. conceptually distinguish between actual and desired employment
     - search and matching models

- Empirically measure latent labor demand
  - vacancy datasets (recruitment effort)

- Determine mapping from measured vacancies into hires
  - Important advances in past decade; still work-in-progress

- We use rich dataset to study
  - Relationship between measured vacancies and hires
  - Implications for aggregate labor markets
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     - vacancy datasets (recruitment effort)
  3. determine mapping from measured vacancies into hires
     - important advances in past decade; still work-in-progress

- We use rich dataset to study
  - Relationship b/w measured vacancies and hires at firm level
  - Firm recruiting, more broadly
  - Implications for aggregate labor markets
This paper

1. Merge online advertisement data with MEE (Denmark)

2. Vacancies and hires:
   - Vacancy yield is stable in the cross-section
   - Across employment growth, hiring rate, size, productivity
   - Different methodology from literature (will discuss in detail)
   - Vacancy rate/yield account for small part of hiring variation

3. Recruiting channels: market, networks, recall (∼40-20-40%)
   - Recall hires are negatively correlated with vacancies
   - Recall hiring is substitute for vacancies
   - Referral network hires are positively correlated with vacancies

4. Matching function volatility ↓ 40% if exclude recall hires
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   - **Recall** hires are *negatively* correlated w/ vacancies
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Data: 2003M1-2009M6, Denmark

1. **Matched employer-employee data**: Stats DK/Aarhus U
   - Workers: employment spells, wages...
   - Firms: employment, hires, separations...

2. **Firm revenues and purchases**: VAT accounts

   ▶ Posts ads directly or reposts from elsewhere ("all online ads")
   ▶ Date of posting (flow), 1-digit occupation
   ▶ 2/3 of ads include firm's Central Business Registry identifier
   ▶ Use CBR identifier to merge with MEE and VAT datasets
   ▶ Discard firms w/o ads in 2003-09 (25% of VA)
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3. **Online job ads**: JobIndex, largest job board in DK
   - Posts ads directly or reposts from elsewhere (“all online ads”)
   - Date of posting (flow), 1-digit occupation
   - 2/3 of ads include firm’s Central Business Registry identifier
     - Use CBR identifier to merge with MEE and VAT datasets
     - Discard firms w/o ads in 2003-09 (25% of VA)
Definition of variables

- Levels, firm $j$:
  - $N_{jt} =$ employment on first day of month $t$ (stock)
  - $H_{jt} =$ number of hires during month $t$ (flow)
  - $S_{jt} =$ number of separations during month $t$ (flow)
  - $V_{jt} =$ number of ads posted during month $t$ (flow)

- Rates, firm $j$, month $t$:
  - Hiring rate: $h_{jt} = \frac{H_{jt}}{0.5(N_{jt}+N_{jt+1})}$
  - Separation rate: $s_{jt} = \frac{S_{jt}}{0.5(N_{jt}+N_{jt+1})}$
  - Vacancy rate: $v_{jt} = \frac{V_{jt}}{V_{jt}+N_{jt}}$
Descriptives

<table>
<thead>
<tr>
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<th>Unweighted</th>
<th>Employment-weighted</th>
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<tbody>
<tr>
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<td>Avg.</td>
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</tr>
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<td>Monthly hiring rate</td>
<td>0.069</td>
<td>0.155</td>
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<tr>
<td>Monthly separation rate</td>
<td>0.066</td>
<td>0.150</td>
</tr>
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<td>Monthly employment growth rate</td>
<td>0.003</td>
<td>0.207</td>
</tr>
<tr>
<td>Monthly vacancy rate</td>
<td>0.010</td>
<td>0.046</td>
</tr>
</tbody>
</table>

Number of firms: 21,160
Number of observations: 1,337,480

\[ \text{Corr}(v, u) = -0.81 \]

- Monthly hiring rate is high (6.9%) and variable (CV > 2)
Empirical challenge

- Want to estimate relationship b/w vacancies and hires

- **Challenge:** many hires occur without measured vacancies
  - JOLTS survey: 42% of hires at establishments w/ 0 vacancies
  - Our data only captures firms’ online recruitment effort

- **Literature** aggregates vacancies & hires for similar firms
  - *Davis, Faberman, Haltiwanger (2013)*; Carrillo-Tudela, Kaas, Gartner (2022); Mongey, Violante (2020); Mueller et al (2023)

- Regression constant: hiring w/o measured vacancies
- Alternative channels, passive search, measurement error...
- Vacuum yield: difference in firm-level hiring w/ vacancies
- If we aggregate: qualitatively similar results to literature
Empirical challenge

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▶ **Our paper**: regress hiring rate on vacancy rate at firm level
  ▶ Regression constant: *hiring w/o measured vacancies*
    ▶ Alternative channels, passive search, measurement error...
  ▶ Vacancy yield: *difference in firm-level hiring w/ vacancies*
  ▶ If we aggregate: qualitatively similar results to literature
A simple model of firm recruiting

- \( h_{jt} = h(e_{jt}|x_{jt}) \)
  - \( h_{jt} \): hiring rate, firm \( j \), month \( t \)
  - \( e_{jt} = (e_{jt}, e_{jt-1}, ...) \) = recruitment effort, including lags
    - Recruitment effort: vacancies and vacancy yield
  - \( x_{jt} \) = month, industry, industry-month effects (aggregates)

- Estimate relationship b/w measured vacancies and hires
Specification (1): static, linear

\[ h_{jt} = \beta + x'_{jt} \delta + \pi_0 v_{jt} + \epsilon_{jt} \]

- \( \beta = \) constant; “no-vacancy hiring rate”
- \( x_{jt} = \) dummies for month, industry, industry-month
- \( \Omega(v) = \) predicted hiring rate with vacancy rate \( v \):
  - \( \pi_0 = \) contemporaneous coefficient
  - \( \Omega(v) = \pi_0 v \)
Specification (2): dynamic, linear

\[ h_{jt} = \beta + x'_{jt} \delta + \sum_{k=0}^{6} \pi_k v_{jt-k} + \epsilon_{jt} \]

- \( \beta \) = constant; “no-vacancy hiring rate”
- \( x_{jt} \) = dummies for month, industry, industry-month

\[ \Omega(v) = \text{predicted hiring rate with vacancy rate } v: \]
  - \( \pi_k \): \( k \)-month lag coefficient
  - \( \Omega(v) = \Pi v \), where \( \Pi = \sum_k \pi_k \) is cumulative coefficient
Specification (3): static, non-linear

- \( h_{jt} = \beta + x'_{jt} \delta + \sum_s \pi^s v_{jt} + \epsilon_{jt} \)

- \( \beta = \text{constant}; \ “\text{no-vacancy hiring rate}” \)

- \( x_{jt} = \text{dummies for month, industry, industry-month} \)

- \( \Omega(v) = \text{predicted hiring rate with vacancy rate } v: \)
  - Piecewise linear \((\sigma_v, 2\sigma_v, 3\sigma_v); \text{ segment } s \text{ coefficient: } \pi^s_0 \)  
  - \( v \in (0, \sigma_v) \Rightarrow \Omega(v) = \pi^1_0 v \)  
  - \( v \in (\sigma_v, 2\sigma_v) \Rightarrow \Omega(v) = \pi^1_0 \sigma_v + \pi^2_0 (v - \sigma_v) \) etc.  

- \( \text{Vacancy yield } = \Psi(v) = \frac{\Omega(v)}{v} \)
Specification (4): dynamic, non-linear

- \( h_{jt} = \beta + x'_{jt} \delta + \sum_{k=0}^{6} \sum_{s} \pi_k^s v_{jt-k} + \epsilon_{jt} \)

- \( \beta = \) constant; “no-vacancy hiring rate”

- \( x_{jt} = \) dummies for month, industry, industry-month

- \( \Omega(v) = \) predicted hiring rate with vacancy rate \( v: \)
  - Piecewise linear \((\sigma_v, 2\sigma_v, 3\sigma_v); \) segment \( s, \) \( k\)-lag coeff.: \( \pi_k^s \)
  - \( v \in (0, \sigma_v) \Rightarrow \Omega(v) = \Pi^1 v \)
  - \( v \in (\sigma_v, 2\sigma_v) \Rightarrow \Omega(v) = \Pi^1 \sigma_v + \Pi^2 (v - \sigma_v), \) etc.

- Vacancy yield = \( \Psi(v) = \frac{\Omega(v)}{v} \)
Specification (5): dynamic, non-linear, fixed-effects

$h_{jt} = \beta + \mathbf{x}_{jt}' \delta + \sum_{k=0}^{6} \sum_{s} \pi_{k}^{s} v_{jt-k} + \rho_{j} + \epsilon_{jt}$

- $\beta$ = constant; “no-vacancy hiring rate”
- $\mathbf{x}_{jt}$ = dummies for month, industry, industry-month

$\Omega(\nu)$ = predicted hiring rate with vacancy rate $\nu$:
  - Piecewise linear ($\sigma_{\nu}$, $2\sigma_{\nu}$, $3\sigma_{\nu}$); segment $s$, $k$-lag coeff.: $\pi_{k}^{s}$
  - $\nu \in (0, \sigma_{\nu}) \implies \Omega(\nu) = \Pi^{1}\nu$
  - $\nu \in (\sigma_{\nu}, 2\sigma_{\nu}) \implies \Omega(\nu) = \Pi^{1}\sigma_{\nu} + \Pi^{2}(\nu - \sigma_{\nu})$, etc.

- Vacancy yield = $\Psi(\nu) = \frac{\Omega(\nu)}{\nu}$

- $\rho_{j}$ = firm $j$ fixed effect
Vacancies and hires

<table>
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<tr>
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<td>$\beta$</td>
<td>0.063***</td>
<td>0.063***</td>
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<td></td>
<td>(0.000)</td>
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<td>(0.012)</td>
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<td>$\pi_6$</td>
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<td>-0.038*</td>
<td>-0.032*</td>
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<td>(0.006)</td>
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<td>(0.020)</td>
<td>(0.018)</td>
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$\Psi(\sigma_v)$

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<td>0.346***</td>
<td>0.370***</td>
<td>0.105***</td>
<td>0.460***</td>
<td>0.423***</td>
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<td>(0.018)</td>
<td>(0.038)</td>
<td>(0.025)</td>
<td>(0.071)</td>
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$\Psi(2\sigma_v)$

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<td>0.346***</td>
<td>0.370***</td>
<td>0.327***</td>
<td>0.561***</td>
<td>0.586***</td>
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<td>(0.018)</td>
<td>(0.038)</td>
<td>(0.019)</td>
<td>(0.052)</td>
<td>(0.039)</td>
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Dynamic effects: significant lagged coefficients (2, 4, 5)
Non-linearities: vacancy yield variation (3,4,5)
Interaction: vacancy yield highest w/ dyn+non-linearities (4,5)
FEs don’t affect estimates. Preferred specification: (4)
1. Online advertisements are predictive of hiring:
   - $\gamma = 4.6\% \text{ (1SD)} \Rightarrow h \uparrow 2.2 \text{ ppts (} \sim 35\% \text{ over } \beta \text{)}$

2. Specification analysis:
   - Hiring elevated for 2-3 months after advertisement observed
   - Vacancy yield increases in vacancy rate
   - Dynamics and non-linearities interact
   - Results are robust if
     - separate regressions for 2003-05 and 2006-09 time periods
     - alternative definition of rates

3. No-vacancy hiring is quantitatively very important
Hiring rate heterogeneity

- Hiring rate varies a lot across time and firms ($CV > 2$)

- Variation in hiring rates associated with variation in:
  1. Vacancy rate ($\nu$): data
  2. Vacancy yield ($\Psi$): *direct estimate*
  3. No-vacancy hiring ($\beta$): residual
Hiring rate heterogeneity

▶ Hiring rate varies a lot across time and firms ($CV > 2$)

▶ Variation in hiring rates associated with variation in:

1. Vacancy rate ($v$): data
2. Vacancy yield ($\Psi$): direct estimate
3. No-vacancy hiring ($\beta$): residual

▶ To evaluate importance of 1-3, we group firm-years by $h$:

▶ $\bar{h}_{j,y} =$ avg monthly hiring rate, firm $j$, calendar year $y$

▶ Allocate firm-year ($j, y$) to bin $b = b(j, y)$ according to $\bar{h}_{j,y}$

▶ 20 equally-sized bins, $\bar{h}_b =$ avg. hiring rate of $b$

▶ Compute $\bar{v}_b$ and estimate $\Psi_b$ and $\beta_b$:

▶ $h_{jt} = \beta_b + \sum_k \sum_s \pi_{k,b}^s v_{jt-k} + x'_{jt} \delta_b + \epsilon_{jt}$
Vacancy rate, by hiring rate bin

- Positive correlation between hiring rate and vacancy rate
- Slope ≈ 0.08-0.15
Vacancy yield, by hiring rate bin

- Yield is essentially flat at 0.15-0.2!
No-vacancy hiring rate, by hiring rate bin

- Variation in $\beta$ accounts for most variation in hiring rate
Taking stock (2)

▶ **Glass half full:** stable relationship between measured inputs (vacancies) and outputs (hires) across:

.getIn  
▶ different hiring rates
▶ different employment growth rates
▶ different employment size and productivity

▶ Glass half empty: variation in measured inputs (vacancies, yield) account for small part of variation in outputs

▶ Non-market recruiting channels?
▶ Measurement error?
Glass half full: stable relationship between measured inputs (vacancies) and outputs (hires) across: 
- different hiring rates 
- different employment growth rates 
- different employment size and productivity 

Glass half empty: variation in measured inputs (vacancies, yield) account for small part of variation in outputs 
- Non-market recruiting channels? 
- Passive search? 
- Measurement error? 
- ...
Hiring channels

- Job advertisements:
  - Initiate contact with workers unconnected to firm
  - Market search

- Many hires occur through non-market channels:
  - *Recall*: re-hiring of previous worker (≈ 40% of hires)
  - *Referral network*: hiring of worker indirectly connected to firm (≈ 20-30% of hires)

- Q: Are non-market hires mediated by vacancies?
A (slightly) more complicated model of firm recruiting

\[ h_{jt} = h^M(e^M_{jt} | x_{jt}) + h^N(e^N_{jt} | x_{jt}) + h^R(e^R_{jt} | x_{jt}) \]

- Recruiting channels: market $M$, referral networks $N$, recall $R$
- Recruitment effort is channel-specific
  - Q: substitutes or complements?
A (slightly) more complicated model of firm recruiting

\[ h_{jt} = h^M(e^M_{jt} \mid x_{jt}) + h^N(e^N_{jt} \mid x_{jt}) + h^R(e^R_{jt} \mid x_{jt}) \]

- Recruiting channels: market \( M \), referral networks \( N \), recall \( R \)
- Recruitment effort is channel-specific
  - Q: substitutes or complements?

- Data:
  - \( h \): total hires
  - \( h^R \): workers previously employed at same firm
  - \( h^N \): coworker networks, subset of all referral hires
  - \( e^M \): online advertisements (NB: JOLTS records \( e^M + e^N \))

- Estimate relationship b/w vacancies and hires through each channel separately
Recalls

- First, examine recall ($R$) and non-recall ($NR = M + N$) hires

- We label a hire as “recall” if newly-hired worker was employed at same firm during previous 2 years.

- Each hire is labeled as R or NR: $h_{jt} = h_{jt}^R + h_{jt}^{NR}$

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Recall</th>
<th>Non-recall</th>
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<tbody>
<tr>
<td>Monthly hiring rate</td>
<td>0.069</td>
<td>0.030</td>
<td>0.039</td>
</tr>
<tr>
<td>Share of total</td>
<td></td>
<td>43.3%</td>
<td>56.7%</td>
</tr>
<tr>
<td>Monthly hiring rate, employment weighted</td>
<td>0.060</td>
<td>0.027</td>
<td>0.033</td>
</tr>
<tr>
<td>Share of total, employment weighted</td>
<td></td>
<td>45.3%</td>
<td>54.7%</td>
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## Vacancies and recall/non-recall hires

<table>
<thead>
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<th></th>
<th>All</th>
<th>Recall</th>
<th>Non-recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.061***</td>
<td>0.030***</td>
<td>0.032***</td>
</tr>
<tr>
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<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Yield ($\sigma_v$)</td>
<td>0.460***</td>
<td>−0.174***</td>
<td>0.634***</td>
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<tr>
<td></td>
<td>(0.071)</td>
<td>(0.039)</td>
<td>(0.046)</td>
</tr>
<tr>
<td>Yield (2$\sigma_v$)</td>
<td>0.561***</td>
<td>−0.035</td>
<td>0.595***</td>
</tr>
<tr>
<td></td>
<td>(0.052)</td>
<td>(0.031)</td>
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</tr>
</tbody>
</table>

|                      | Yes | Yes | Yes |
| Dynamic effects      |     |     |     |
| Nonlinear effects    | Yes | Yes | Yes |
| Firm fixed effects   | No  | No  | No  |

- Measured vacancies associated with fewer recall hires!
- Alternative definitions of recall yield same result

- Removing recalls: $\uparrow$ vacancy yield, $\downarrow$ no-vacancy hiring rate
  - $v = 4.6\%$ (1SD) $\Rightarrow$ $h \uparrow 2.9$ ppts, 91% of $\beta$
Taking stock (3)

- An interpretation: when a firm wants to hire
  - First, it tries recalling worker(s) previously employed there
  - If recall insufficient, then it searches through market
    - Recall effort is substitute for market effort
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  - First, it tries recalling worker(s) previously employed there
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- Implication for theory:
  - Cost of screening new workers is very high

- Implications for measurement:
  - Measured vacancies capture *subset* of latent labor demand
  - Need to distinguish b/w $R$ and $NR$ hires in data
  - Need to create a measure of recallable workers
Referral networks

- Investigate market and referral network hires separately

- Identify referral hires from coworker networks (subset):
  - Worker $i$ hired by firm $j$ at $t$. Denote:
    - $E(i, s) =$ employer of $i$ in month $s = t - 37, \ldots, t - 1$
    - $E(k, s) =$ employer of $k$ in $s$, for all current firm-$j$ workers $k$
  - If $E(i, s) = E(k, s)$, some $k, s$ ($i, k$ co-workers), then referral took place (Hensvik-Skans 2016, Glitz-Vejlin 2021)
Referral networks

- Investigate market and referral network hires separately

- Identify referral hires from coworker networks (subset):
  - Worker $i$ hired by firm $j$ at $t$. Denote:
    - $E(i, s) = $ employer of $i$ in month $s = t - 37, \ldots, t - 1$
    - $E(k, s) = $ employer of $k$ in $s$, for all current firm-$j$ workers $k$
  - If $E(i, s) = E(k, s)$, some $k, s$ ($i, k$ co-workers), then referral took place (Hensvik-Skans 2016, Glitz-Vejlin 2021)

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Recall</th>
<th>Referral</th>
<th>Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly hiring rate</td>
<td>0.069</td>
<td>0.030</td>
<td>0.006</td>
<td>0.033</td>
</tr>
<tr>
<td>Share of total</td>
<td>43.3%</td>
<td>8.5%</td>
<td>48.3%</td>
<td></td>
</tr>
<tr>
<td>Monthly hiring rate, employment weighted</td>
<td>0.060</td>
<td>0.027</td>
<td>0.012</td>
<td>0.021</td>
</tr>
<tr>
<td>Share of total, employment weighted</td>
<td>45.3%</td>
<td>19.9%</td>
<td>34.8%</td>
<td></td>
</tr>
</tbody>
</table>

- Coworker networks identify referrals at large firms, mostly
Vacancies and recall/network/market hires

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Recall</th>
<th>Network</th>
<th>Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.061*** (0.000)</td>
<td>0.030*** (0.000)</td>
<td>0.004*** (0.000)</td>
<td>0.028*** (0.000)</td>
</tr>
<tr>
<td>Yield ($\sigma_v$)</td>
<td>0.460*** (0.071)</td>
<td>-0.174*** (0.039)</td>
<td>0.474*** (0.019)</td>
<td>0.160*** (0.034)</td>
</tr>
<tr>
<td>Yield ($2\sigma_v$)</td>
<td>0.561*** (0.039)</td>
<td>-0.035 (0.031)</td>
<td>0.018 (0.014)</td>
<td>0.577*** (0.027)</td>
</tr>
<tr>
<td>Dynamic effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Nonlinear effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Firm fixed effects</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

- Positive correlation b/w vacancies and network hires
  - High estimate of vacancy yield for network hires; lower with fixed effects
  
- Taking stock (4):
  - Market effort and referral network effort are complements
  - Suffices to focus on recall vs no-recall hires
Implications for aggregate labor markets

- Job-finding and job-filling fluctuate more than tightness
- Volatile matching efficiency, cyclical search effort, changing composition of $u$ and/or $v$...
Implications for aggregate labor markets

- Job-finding and job-filling fluctuate more than tightness
  - Volatile matching efficiency, cyclical search effort, changing composition of $u$ and/or $v$...

- Recall hires
  - in cross-section: uncorrelated w/ vacancies
  - in aggregate: uncorrelated w/ tightness: $\text{corr}(h^R, v/u) = 0.065$
  - might exacerbate matching function volatility?
Matching function estimation

- Matching function \( h_t = \mu_t v_t^\eta u_t^{1-\eta} \). Estimate
  
  \[ \ln\left(\frac{h_t}{v_t}\right) = -(1 - \eta) \ln\left(\frac{v_t}{u_t}\right) + \ln(\mu_0) + d_{m(t)} + \zeta t + \epsilon_t \]

  - \( v_t \) = aggregate vacancy rate \( v_t \) (our data)
  - \( u_t \) = unemployment rate (LFS)
  - Calendar month dummy, linear trend
  - Hiring rate \( h_t \): total vs non-recall; \( NE + EE \) and \( NE \)

- Measure of matching function stability: \( \text{std dev}(\hat{\epsilon}_t) \)

<table>
<thead>
<tr>
<th>Standard deviation (( \hat{\epsilon}_t ))</th>
<th>( NE + EE )</th>
<th>( NE )</th>
</tr>
</thead>
<tbody>
<tr>
<td>All channels</td>
<td>0.138</td>
<td>0.186</td>
</tr>
<tr>
<td>Non-recall</td>
<td>0.073</td>
<td>0.109</td>
</tr>
<tr>
<td>Difference</td>
<td>-47%</td>
<td>-41%</td>
</tr>
</tbody>
</table>
Conclusions

- We merge online advertisement data with MEE to investigate relation b/w vacancies and hires

- In the cross-section:
  - the vacancy yield is stable
  - measured vacancies do not account for hiring variation

- Recall hires negatively correlated with firms’ market recruitment effort

- Removing recall hires improves matching function prediction
### Firms with/without online job advertisements

<table>
<thead>
<tr>
<th></th>
<th>w/ online job advert.</th>
<th>w/o online job advert.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of firms</td>
<td>21,160</td>
<td>105,204</td>
</tr>
<tr>
<td>Number of observations</td>
<td>1,337,480</td>
<td>2,607,050</td>
</tr>
<tr>
<td>Employment per firm-month</td>
<td>48.4</td>
<td>9.5</td>
</tr>
<tr>
<td>Revenue per firm-month (in DKK 1,000)</td>
<td>7,670.7</td>
<td>1,275.5</td>
</tr>
<tr>
<td>Value added per firm-month (in DKK 1,000)</td>
<td>2,359.7</td>
<td>387.9</td>
</tr>
<tr>
<td>Hires per firm-month</td>
<td>2.9</td>
<td>0.7</td>
</tr>
<tr>
<td>Net job creation</td>
<td>90,697</td>
<td>-40,391</td>
</tr>
<tr>
<td>Share of total employment</td>
<td>0.723</td>
<td>0.277</td>
</tr>
<tr>
<td>Share of total revenue</td>
<td>0.755</td>
<td>0.245</td>
</tr>
<tr>
<td>Share of total value added</td>
<td>0.757</td>
<td>0.243</td>
</tr>
<tr>
<td>Share of hires</td>
<td>0.687</td>
<td>0.313</td>
</tr>
<tr>
<td>Share of net job creation</td>
<td>1.803</td>
<td>-0.803</td>
</tr>
</tbody>
</table>

Note: 1 USD = 6.2 DKK in March 2021
Alternative definition of rates

- $\bar{N}_j$: average employment at $j$ in 2003M1-2009M6

- $h_{jt} = \frac{H_{jt}}{\bar{N}_j}$

- $s_{jt} = \frac{S_{jt}}{\bar{N}_j}$

- $v_{jt} = \frac{V_{jt}}{(V_{jt} + \bar{N}_j)}$
Alternative definition of rates ($\bar{N}_j$)

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Non-recall</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.059***</td>
<td>0.040***</td>
<td>0.019***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>$\Omega(\sigma_v)\sigma_v$</td>
<td>0.732***</td>
<td>0.757***</td>
<td>$-0.024$</td>
</tr>
<tr>
<td></td>
<td>(0.078)</td>
<td>(0.064)</td>
<td>(0.028)</td>
</tr>
<tr>
<td>$\Omega(2\sigma_v)/(2\sigma_v)$</td>
<td>0.778***</td>
<td>0.802***</td>
<td>$-0.024$</td>
</tr>
<tr>
<td></td>
<td>(0.062)</td>
<td>(0.051)</td>
<td>(0.023)</td>
</tr>
<tr>
<td>Dynamic effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Nonlinear effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

- Similar qualitative patterns, slightly higher estimates
Higher estimated effects in early period
Q: does hiring yield vary with firm productivity?

Group firms by value added per worker

 Allocate firm \((j)\) to bin \(b(j)\) by avg VA/worker (2003-09)

  20 equally-sized bins

Estimate pref. spec. for non-recall hires, where \(b = b(j)\):

\[
 h_{jt} = \beta_b + \sum_k \sum_s \pi_{k,b}^s v_{jt-k} + x_{jt}' \delta_b + \epsilon_{jt}
\]

Report yield \((\Psi(\nu))\) and no-vacancy hiring rate \((\beta)\)
Hires, vacancies, and yield by productivity

Hiring rate vs productivity

No-vacancy hiring rate vs productivity

Vacancy rate vs productivity

Vacancy yield vs productivity
Q: does hiring yield vary with firm size?

Group firms by average number of workers
- Allocate firm \( (j) \) to bin \( b(j) \) by avg # workers (2003-09)
  - 20 equally-sized bins

Estimate pref. spec. for non-recall hires, where \( b = b(j) \):

\[
h_{jt} = \beta_b + \sum_k \sum_s \pi_{k,b}^s v_{jt-k} + x'_{jt} \delta_b + \epsilon_{jt}
\]

Report yield \((\Omega(v)/v)\) and no-vacancy hiring rate \((\beta)\)
Hires, vacancies, and yield by employment size

- Hiring rate vs employment size
- No-vacancy hiring rate vs employment size
- Vacancy rate vs employment size
- Vacancy yield vs employment size
Heterogeneity: firm employment growth rate

▷ Q: Does vacancy yield vary with employment growth rate?

▷ Group firm-years by employment growth rate:
  ▷ \( g_{j,y} = \text{avg monthly empl. growth rate, firm } j, \text{ calendar year } y \)
  ▷ Allocate firm-year \((j, y)\) to bin \(b(j, y)\) according to \(g_{j,y}\)
    ▷ 20 equally-sized bins + \([g = 0]\)

▷ Estimate preferred specification for each bin
  ▷ \( h_{jt} = \beta_b + \sum_k \sum_s \pi_{k,b} v_{jt-k} + x'_{jt} \delta_b + \epsilon_{jt} \)

▷ Report vacancy rate \(\bar{v}_b\), vacancy yield \((\Psi_b)\) and no-vacancy hiring rate \((\beta_b)\) for each bin
Hires, Vacancies, and yield by employment growth

- **Hiring rate vs employment growth**
- **No-vacancy hiring rate vs employment growth**
- **Vacancy rate vs employment growth**
- **Vacancy yield vs employment growth**
Group firm-months according to monthly employment growth

- \( D_{jt}^b \) is dummy for firm-month \((j, t)\) and bin \(b\)

Estimate

- \( h_{jt} = \sum_b \gamma_h^b D_{jt}^b + x'_{jt} \delta_h + \rho_j + \epsilon_{jt} \)
- \( v_{jt} = \sum_b \gamma_v^b D_{jt}^b + x'_{jt} \delta_v + \rho_j + \epsilon_{jt} \)

Hockey stick graphs: plot avg. growth rate in bin \(b\) against

- Hiring rate: \( \gamma_h^b \)
- Vacancy rate: \( \gamma_v^b \)
- Vacancy yield: \( \frac{\gamma_h^b}{\gamma_v^b} \)
Hockey sticks in Danish data

- Hiring rate vs employment growth
- Vacancy rate vs employment growth
- Vacancy yield vs employment growth
- Non-recall vacancy yield vs employment growth
Hockey sticks in JOLTS (DFH 2013)

Hiring rate vs employment growth

Vacancy rate vs employment growth

Vacancy yield vs employment growth
Alternative definitions of recall

Out of all hires at firm $j$:

1. 32.0% are from non-employment w previous job at $j$
2. 31.8% observed as firm-$j$ employee in past 92 days
3. 36.4% observed as firm-$j$ employee in past 183 days
4. 41.3% observed as firm-$j$ employee in past 365 days
5. 43.3% observed as firm-$j$ employee in past 730 days
6. 44.0% observed as firm-$j$ employee in past 1095 days
7. 44.6% observed as firm-$j$ employee in past 1825 days
8. 45.2% observed as firm-$j$ employee at any time in the past
Recall hires are negatively correlated with vacancy-posting in all recall definitions.
### Vacancies and recall/network/market hires - FE

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<td>0.029*** (0.000)</td>
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<td>0.027*** (0.000)</td>
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<tr>
<td>Yield ($\sigma_v$)</td>
<td>0.423*** (0.048)</td>
<td>-0.227*** (0.039)</td>
<td>0.135*** (0.010)</td>
<td>0.515*** (0.022)</td>
</tr>
<tr>
<td>Yield ($2\sigma_v$)</td>
<td>0.586*** (0.039)</td>
<td>0.056* (0.030)</td>
<td>0.049*** (0.008)</td>
<td>0.481*** (0.020)</td>
</tr>
<tr>
<td>Dynamic effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
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<td>Yes</td>
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<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- Qualitatively, same pattern: positive correlation b/w $h^N$ and $v$
- Quantitatively, vacancy yield is lower for $h^N$ than for $h^M$

- Large firms:
  - Post vacancies more frequently
  - Hire through co-worker networks more intensely
- Fixed effects control for correlation between network hiring and frequency of vacancy-posting.
Measurement error example

Static, linear model: \( h^* = \beta + \pi v^* + \epsilon \)

- Vacancies are measured with classical error: \( v = v^* + e \)
- Hires are measured perfectly (immaterial): \( h = h^* \)
Measurement error example

Static, linear model: \( h^* = \beta + \pi v^* + \epsilon \)

- Vacancies are measured with classical error: \( v = v^* + e \)
- Hires are measured perfectly (immaterial): \( h = h^* \)

OLS regression of \( h \) on \( v \):

- \( \hat{\pi} \xrightarrow{p} \pi \frac{\sigma_v^2}{\sigma_{v^*}^2 + \sigma_e^2} < \pi \)
- \( \hat{\beta} \xrightarrow{p} \beta + \pi \frac{\sigma_v^2}{\sigma_{v^*}^2 + \sigma_e^2} \mu v^* > \beta \)

1. Attenuation bias reduces \( v \)-coefficient, increases constant
Measurement error example

Static, linear model: \( h^* = \beta + \pi v^* + \epsilon \)

- Vacancies are measured with classical error: \( v = v^* + e \)
- Hires are measured perfectly (immaterial): \( h = h^* \)

OLS regression of \( h \) on \( v \):

\[
\hat{\pi} \xrightarrow{p} \pi \frac{\sigma^2_{v*}}{\sigma^2_{v*} + \sigma^2_e} < \pi \\
\hat{\beta} \xrightarrow{p} \beta + \pi \frac{\sigma^2_{v*}}{\sigma^2_{v*} + \sigma^2_e} \mu v^* > \beta
\]

1. Attenuation bias reduces \( v \)-coefficient, increases constant

Heterogeneity in \( h \), bin \( b \): \( \hat{\pi}_b (1 + \frac{\sigma^2_{e,b}}{\sigma^2_{v*,b}}) \xrightarrow{p} \pi_b \)

- Estimation: \( \hat{\pi}_b \) constant across bins (\( h \))
  - \( \pi_b \) increases in \( h \) if \( \frac{\sigma^2_{e,b}}{\sigma^2_{v*,b}} \) increases in \( b \)
- Data: \( \sigma^2_{v*,b} + \sigma^2_{e,b} \uparrow \) in \( h \)

2. Does \( \sigma^2_{e,b} \) increase more than \( \sigma^2_{v*,b} \) for high-\( h \)?