A Tale of Two Workers: The Macroeconomics of Automation

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UZH & CEPR, TAU & UCL, UBC & NBER, IDC

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Motivation: why are we here?

- Automation, computing, robotics (”automation technology”):
  - These words have become part of our everyday lexicon as the processes behind them have transformed the nature of work.

- These advances have not only made us more productive:
  - Induce large-scale shifts in the types of jobs performed in the economy (e.g. Autor, Katz, and Kearney (2006)).
Motivation: why are we here?

- The U.S. economy has seen a sharp drop in the fraction of the population employed in Routine occupations:
  - Focused on a relatively narrow set of job tasks that can be performed by following well-defined instructions and procedures and which, by their nature, are prime candidates to be performed by new automation technologies.
- Routine occupations tend to represent middle-class jobs →
  - Increasing polarization of the labor market, as employment shares have shifted toward non-routine cognitive occupations and non-routine manual occupations.
So what is new?

- Data: New (hopefully important) facts
- Quantitative Theory: Can it explain the key facts?
  - Yes...
So what is new?

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- How do we evaluate the types of macro policies that have been discussed yesterday?
- How do you run your business?
So what is new?

- Data: New (hopefully important) facts
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- How do we evaluate the types of macro policies that have been discussed yesterday?
- How do you run your business?
  - Cost/Benefit
  - Welfare
  - Taxation
- Policy evaluation: Use the model as a "lab"
What is Job Polarization?
A Quick Reminder: What is Job Polarization?

- **Non-Routine Cognitive** (high-skill): public relations manager, physician, financial analyst, teacher, computer programmer, economist

- **Routine** (Middle-Skill):
  - Cognitive: secretary, bank teller, retail salesperson, travel agent, mail clerk, office support worker, data entry keyer
  - Manual: machine operator, machine tender, fabricator/assembler, welder, mechanic, cement mason, dressmaker, butcher

- **Non-Routine Manual** (low-skill): janitor, bus-boy, gardener, bartender, manicurist, personal care worker
A Quick Reminder: What is Job Polarization?
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![Chart showing percent change in job polarization]

- **Non-Routine Cognitive**
  - 1982-1992: 8.2%
  - 1992-2002: 10.6%
  - 2002-2012: 9.6%

- **Routine**
  - 1982-1992: -4.5%
  - 1992-2002: -6.7%

- **Non-Routine Manual**
  - 1982-1992: 0.8%
  - 1992-2002: 1.3%
  - 2002-2012: 12.0%

Percent change in job polarization from 1982 to 2012:
- Non-Routine Cognitive: 29% to 38%
- Routine: 56% to 44%
- Non-Routine Manual: 15% to 19%
A Quick Reminder: What is Job Polarization?
Job Polarization: According to Robert Steven Kaplan
WSJ, 10/10/2018

...In the middle ... two powerful forces going on, which are automation and globalization...

...The next thing CEO talk about is their plans to replace people with technology...oh my lord, you know, every industry is busy replacing people with technology and labor-saving devices

The concerning things are this issue of lagging education, lagging skills training .... that could take advantage of all this technology investment.. That's probably the primary concern I have
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Data
What happened to people with "Routine Characteristics"?

- Study the evolution of people with Routine characteristics.
  - Have they become Economics professors?
  - Have they become janitors?
  - Have they simply stopped working?
What happened to people with "Routine Characteristics"?

- Study the evolution of people with Routine characteristics.
  - Have they become Economics professors?
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  - Have they simply stopped working?

- But wait a sec... what are "Routine characteristics"?
How to classify the routine workers?

- This is a classical machine learning classification problem

- Use pre-polarizartion data of employed (CPS 1984-1989) to train a "Random Forest Algorithm" to classify TYPES or workers:
  - Flexibly uses age, education, gender, race.
  - With an eye on the theoretical model, classify into:
    1. Non-routine-cognitive (NRC)
    2. Other occupations (Non-NRC; "Unskilled")

Precision and Recall
Extraction of clean series
Lost R are found in NLF (2/3) and NRM (1/3)

<table>
<thead>
<tr>
<th>“Unskilled”</th>
<th>(1)</th>
<th>(2)</th>
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<tr>
<td>Fraction in R</td>
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1. NLF accounts for 2/3 of the fall in ER, and ENRM for 1/3.
2. Employment at NRC and unemployment are stable.
3. Changes in NLF and NRM are NOT observed for NRC.
Lost \( R \) are found in NLF (2/3) and NRM (1/3)

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<td>Fraction in Unemployment</td>
<td>~0</td>
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<td>Fraction in Unemployment</td>
<td>0.05</td>
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<tr>
<td>Unemployment rate</td>
<td>0.06</td>
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<td>Population Weight</td>
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Model
The Basic Story

- Workers have abilities as factory workers and personal care
- Given equilibrium prices, outside options, taxes, sort across:
  - Occupation (R,NRM)
  - Labor status (E,U,NLF)
- Optimal (profit maximization) decisions by firm
- In General Equilibrium: Everything is consistent....
- In technical terms: A GE Roy Model with lots of stuff...
The Basic Story

NRM

NLF

R

Slope = \frac{\epsilon_{NR}}{\epsilon_R} = \frac{P_R F_R}{P_{NR} F_{NR}}

\epsilon^*_R: V^u_R(\epsilon^*_R) = \text{Outside Option}

\epsilon^*_NRM: V^u_{NRM}(\epsilon^*_NRM) = \text{Outside Option}

\epsilon_{NRM}
The Basic Story

\[
\text{Slope} = \frac{\epsilon_{NR}}{\epsilon_R} = \frac{P_{new}^R P_{new}^R}{P_{new}^NR P_{new}^NR}
\]
Policies

- In equilibrium policies are statements about:
  1. Changes in the slope of the diagonal
  2. Potentially changing the ability distribution
  3. Potentially departing from a "straight" diagonal and introducing curvature
Description of the Model

- How do we produce "stuff"?

\[ Y_t = Z_t K_t^\gamma \left( (1-\eta) \left[ (1-\alpha) Y_{NRC,t}^{EOS1} + \alpha \left[ X^\nu_A + Y_{R,t}^\nu \right] \frac{EOS1}{EOS1} \right] + \eta Y_{NRM,t}^{EOS2} \right)^{1-\gamma} \]

- Two types of capital
  - **Important**: degree of adoption of ICT is **endogenous** in a GE model
  - Responds to shocks and policy → affects R

- Three occupations
  - Employment, Unemployment (DMP model) and LF
ICT Cost

Data: Eden and Gaggl (2018) from BEA detailed fixed asset accounts (quality adjusted prices and stocks of ICT)
Assume a worker with $\epsilon = \{\epsilon_R, \epsilon_{NR}\}$

**Worker’s value if employed in R:**

$$V_{e,R,\epsilon}(\Lambda) = \max_{C_{e,R,\epsilon}} \left\{ U(C_{e,R,\epsilon}) + \beta (1 - \delta_R) \times \right.$$  

$$\left. \begin{align*}
\max & \quad E \left[ \max \{ V_{e,R,\epsilon}(\Lambda'), V_{u,R,\epsilon}(\Lambda'), V_{u,NRM,\epsilon}(\Lambda'), V_{o,\epsilon}(\Lambda') \} \right] + \\
& \quad \beta \delta_R \times E \left[ \max \{ V_{u,R,\epsilon}(\Lambda'), V_{u,NRM,\epsilon}(\Lambda'), V_{o,\epsilon}(\Lambda') \} \right] \right\}$$

$s.t. : C_{e,R,\epsilon} = \omega_{R,\epsilon} (1 - T_{e,R,\epsilon}) + \text{Gov Transfer}$
Description of the Model

- Basically: Tons of equations...

- But importantly: everything holds together in a GE model of the economy

- Can evaluate policies and the response of the economy
Model Results
<table>
<thead>
<tr>
<th>Introduction</th>
<th>Overview</th>
<th>Data</th>
<th>Results</th>
<th>Policy Experiments</th>
</tr>
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</table>

Or: why should we care about the policy implications?
# Moments to Remember

<table>
<thead>
<tr>
<th>First Moments : Targeted</th>
<th>Data</th>
<th>Model</th>
<th>Relevant Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Labor Share</td>
<td>0.629</td>
<td>0.629</td>
<td>(\alpha, \eta, F_R, \tau_R)</td>
</tr>
<tr>
<td>Routine Labor Share</td>
<td>0.30</td>
<td>0.30</td>
<td>(\alpha, \eta, F_R, \tau_R)</td>
</tr>
<tr>
<td>ICT Share</td>
<td>0.029</td>
<td>0.029</td>
<td>(\alpha, \eta, F_R, \tau_R)</td>
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<tr>
<td>Indifference Condition</td>
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<tbody>
<tr>
<td>Change in ratio of XA/ER</td>
<td>8.45</td>
<td>8.45</td>
<td>(\nu, EOS_1, \Delta \phi_A)</td>
</tr>
<tr>
<td>Fraction of (\Delta R): NLF</td>
<td>0.66</td>
<td>0.66</td>
<td>(\nu, EOS_1, \Delta \phi_A)</td>
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<tr>
<td>Relative fall in (\phi)</td>
<td>0.4</td>
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Ok: looks like a good description of the economy! So what are the effects?!
The Effects of Automation

- Output increases by 13%
- Overall, economy wide: welfare increases by 2.5%
The Effects of Automation

- Output increases by 13%
- Overall, economy wide: welfare increases by 2.5%
- NRC: welfare increases by 25%
  - Labor market: benefit from complementarity with ICT
  - Hold firm equity
The Effects of Automation

- Output increases by 13%
- Overall, economy wide: welfare increases by 2.5%
- NRC: welfare increases by 25%
  - Labor market: benefit from complementarity with ICT
  - Hold firm equity
- But...for "Unskilled"
  - LF decreases by 4.5 pp
  - R falls by 6.5pp
  - NRM increases by 2pp
Welfare Results

\[ \varepsilon_{\text{NRM}}: V^{u}_{\text{NRM}}(\varepsilon^*_{\text{NRM}}) = \text{Outside Option} \]

\[ \varepsilon^*_{\text{NRM}}: V^{u}_{\text{R}}(\varepsilon^*_{\text{R}}) = \text{Outside Option} \]
Welfare Results

The diagram illustrates the relationship between different regions labeled as NRM, NLF, and R, with axes labeled as $\epsilon_{NRM}$ and $\epsilon_R$. The regions are color-coded and divided by dashed lines.
Welfare Results

\[ \epsilon_{NRM} \]

\[ NRM \rightarrow NRM \]

\[ \text{NLF} \rightarrow NRM \]

\[ NLF \rightarrow NLF \]

\[ R \rightarrow NRM \]

\[ R \rightarrow \text{NLF} \]

\[ R \rightarrow R \]
Welfare Results

- $NRM \rightarrow NRM$: +4.5%
- $NLF \rightarrow NRM$: +3%
- $NLF \rightarrow NLF$: 0%
- $R \rightarrow NRM$: −4%
- $R \rightarrow NLF$: −7%
- $R \rightarrow R$: −12%
Experiments: Return LF to Initial Level
Policy Experiments

- GE empirically relevant model: worthwhile to evaluate policies

- Unfortunately policies have to be financed...consider:
  - Profit taxation
  - Analyze the distributional consequences policies.
Policy Experiments: Two Sets of Policies

- Study the effects of policies that are aimed directly at counteracting the negative effects of ICT.
  - **ICT taxing**
    - Analyze the equilibrium consequences of policies that change the abilities of workers in the face of changes in ICT.
      1. From MFG to Personal Care Worker (the skills of tomorrow)
      2. From MFG to better MFG worker (the skills of yesterday)
      3. From MFG to Economist (the no skills?!)
Policy Experiments: Two Sets of Policies

- Study the effects of policies that could address challenges associated with employment disappearance
  - **Universal Basic Income: Two alternative methods**
  - Different reforms in unemployment insurance benefits
  - Changes in ”Disability” transfers
  - Changes in minimum wages
Experiments
All you need to know about Robots Taxing

- Optimal ICT investment:

\[
\phi_A = \frac{\beta}{(1 - \beta(1 - \delta_A))}^{MPA}
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Experiments
All you need to know about Robots Taxing

- Optimal ICT investment:

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\rightarrow (1 + \tau_A)\phi_A = \frac{\beta}{(1 - \beta(1 - \delta_A))} \quad \text{MPA}
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- There is a tax that "turns back the clock"
Experiments
All you need to know about Robots Taxing

- Optimal ICT investment:

\[ \phi_A = \frac{\beta}{(1 - \beta(1 - \delta_A))} MPA \]

\[ \rightarrow (1 + \tau_A)\phi_A = \frac{\beta}{(1 - \beta(1 - \delta_A))} MPA \]

- There is a tax that "turns back the clock"

- As ICT prices keep on falling required tax keeps on increasing...

- Do we really think a 300% tax rate is realistic?
Experiments: From MFG to Personal Care Worker

Increase NRM ability

▶ ”Retrain” a segment of the population:
  ▶ Those who are NLF after the ICT change

▶ Solve for the GE allocation
Experiments: From MFG to Personal Care Worker

Increase NRM ability

- Overall, economy wide: welfare increases by 4.2%
Experiments: From MFG to Personal Care Worker

Increase NRM ability

- Overall, economy wide: welfare increases by 4.2%
- Output increases by 2.9%

But...for Unskilled

Some winners and some losers...

Those who get the retraining win: +11%

Displacing existing NRM workers: −16%

But someone has to pay for the program...
Experiments: From MFG to Personal Care Worker
Increase NRM ability

- Overall, economy wide: welfare increases by 4.2%
- Output increases by 2.9%
- R does not change → increase in NRM

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- Overall, economy wide: welfare increases by 4.2%
- Output increases by 2.9%
- $R$ does not change $\rightarrow$ increase in NRM
- Tax on profits falls by 8%

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But someone has to pay for the program....
Experiments: From MFG to Personal Care Worker

Increase NRM ability

- Movement of 7pp into of LF: "Treated population"
- Gains in GDP 2.9%
- As long as program cost per participant is less than 44% of GDP per capita it pays off
- Cost could be higher if profit taxation is rolled back to initial level
Experiments: UBI

13% of average routine wage

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$\Delta \text{GDP}$ -8.7%
Experiments: UBI

13% of average routine wage

\[ LF \quad +4.5\text{pp} \]
\[ ER \quad +2.8\text{pp} \]
\[ NRM \quad +1.7\text{pp} \]
\[ \Delta GDP \quad -8.7\% \]
Experiments: UBI

Wages by ability vs. benchmark case
Experiments: UBI
13% of average routine wage

$LF$ 4.5pp

$ER$ +2.8pp

$NRM$ +1.7pp

$\Delta GDP$ -8.7%

Employment Rate ER 80%

Employment Rate ENRM 80%

Agg Labor Share -0.0343

Routine labor share -0.0108
Experiments: UBI
13% of average routine wage

- Overall, economy wide: welfare increases by 18%

NRC: welfare decreases by 16%

For "Unskilled": welfare increase by about 30%

But someone has to pay for the program....taxes on profit increases by 15%
Experiments: UBI

13% of average routine wage

- Overall, economy wide: welfare increases by 18%
- Output decreases by 8.7%

NRC: welfare decreases by 16%

For "Unskilled": welfare increase by about 30%

But someone has to pay for the program....taxes on profit increases by 15%
Experiments: UBI

13% of average routine wage

- Overall, economy wide: welfare increases by 18%
- Output decreases by 8.7%
- NRC: welfare decreases by 16%

But someone has to pay for the program... taxes on profit increases by 15%
Experiments: UBI
13% of average routine wage

- Overall, economy wide: welfare increases by 18%
- Output decreases by 8.7%
- NRC: welfare decreases by 16%
- For ”Unskilled”: welfare increase by about 30%

But someone has to pay for the program....taxes on profit increases by 15%
Experiments: UBI
13% of average routine wage

- Overall, economy wide: welfare increases by 18%
- Output decreases by 8.7%
- NRC: welfare decreases by 16%
- For "Unskilled": welfare increase by about 30%
- But someone has to pay for the program....taxes on profit increases by 15%
Conclusions

- NLF accounts for 2/3 of the fall in ER, and ENRM for 1/3
- Quantitative GE model of Automation
  - Significant winners and losers
- Policy experiments
  - Consider a variety of experiments
  - Retraining offers the "best" return
- Exciting (at least to us) framework to analyze the consequence of a variety of policies
  - So which policy is on your mind?
Appendix
Looking at conditional responses

- A (business cycle) shock based explanation for jobless recoveries.

- Without getting into too many details....a six lag monthly VAR with employment, IP, stock prices

  1. "Local projection methods" (e.g. Jorda (2005) and Ramey and Zubairy (2018)): response to Financial, TFP, Monetary shocks.

  2. "Augmented” VAR sign restrictions.
Employment response to Financial Shocks

- Full Sample
- Pre-1990
- Post-1990
- Recession and Pre-1990
- Non-Recession and Pre-1990
- Recession and Post-1990
- Non-Recession and Post-1990

Contribution Difference: Recession and Post-1990 Vs. Recession and Pre-1990

Employment response to Financial Shocks

- **Full Sample**
- **Pre-1990**
- **Post-1990**

- **Recession and Pre-1990**
- **Non-Recession and Pre-1990**
- **Recession and Post-1990**
- **Non-Recession and Post-1990**

Response Difference: Recession and Post-1990 Vs. Recession and Pre-1990
Employment response to TFP Shocks
Employment response to TFP Shocks

- Full Sample
- Pre-1990
- Post-1990
- Recession and Pre-1990
- Non-Recession and Pre-1990
- Recession and Post-1990
- Non-Recession and Post-1990

Response Difference: Recession and Post-1990 Vs. Recession and Pre-1990
Employment response to Monetary Shocks

- Full Sample
- Pre-1990
- Post-1990
- Recession and Pre-1990
- Non-Recession and Pre-1990
- Recession and Post-1990
- Non-Recession and Post-1990

Contribution Difference: Recession and Post-1990 Vs. Recession and Pre-1990

Employment response to Monetary Shocks

- Full Sample
- Pre-1990
- Post-1990
- Recession and Pre-1990
- Non-Recession and Pre-1990
- Recession and Post-1990
- Non-Recession and Post-1990

Response Difference: Recession and Post-1990 Vs. Recession and Pre-1990

Summary

- Lack of employment recovery in response to all shocks post "polarization"
- Separate into $R\&NR$
NR response to Financial Shocks

Full Sample

Pre-1990

Post-1990

Recession and Pre-1990

Non-Recession and Pre-1990

Recession and Post-1990

Non-Recession and Post-1990

Response Difference: Recession and Post-1990 Vs. Recession and Pre-1990

R response to Financial Shocks

```
<table>
<thead>
<tr>
<th></th>
<th>Percentage Points</th>
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<tbody>
<tr>
<td>Full Sample</td>
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<tr>
<td>Pre-1990</td>
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<tr>
<td>Post-1990</td>
<td></td>
</tr>
<tr>
<td>Recession and Pre-1990</td>
<td></td>
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<tr>
<td>Non-Recession and Pre-1990</td>
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<tr>
<td>Recession and Post-1990</td>
<td></td>
</tr>
<tr>
<td>Non-Recession and Post-1990</td>
<td></td>
</tr>
</tbody>
</table>

Response Difference: Recession and Post-1990 Vs. Recession and Pre-1990

```
NR response to Monetary Shocks
R response to Monetary Shocks

- **Full Sample**
- **Pre-1990**
- **Post-1990**
- **Recession and Pre-1990**
- **Non-Recession and Pre-1990**
- **Recession and Post-1990**
- **Non-Recession and Post-1990**

**Response Difference:**
- Recession and Post-1990 Vs. Recession and Pre-1990
- Non-Recession and Post-1990 Vs. Non-Recession and Pre-1990
NR response to TFP Shocks

- Full Sample
- Pre-1990
- Post-1990
- Recession and Pre-1990
- Non-Recession and Pre-1990
- Recession and Post-1990
- Non-Recession and Post-1990

Response Difference: Recession and Post-1990 Vs. Recession and Pre-1990

R response to TFP Shocks

- **Full Sample**
- **Pre-1990**
- **Post-1990**
- **Recession and Pre-1990**
- **Non-Recession and Pre-1990**
- **Recession and Post-1990**
- **Non-Recession and Post-1990**

**Response Difference:**
- Recession and Post-1990 Vs. Recession and Pre-1990
- Non-Recession and Post-1990 Vs. Non-Recession and Pre-1990
NR response to Bus Cycle Shocks

- Full Sample
- Pre-1990
- Post-1990
- Recession and Pre-1990
- Non-Recession and Pre-1990
- Recession and Post-1990
- Non-Recession and Post-1990

Response Difference: Recession and Post-1990 Vs. Recession and Pre-1990
NR response to Bus Cycle Shocks

- **Full Sample**
- **Pre-1990**
- **Post-1990**
- **Recession and Pre-1990**
- **Non-Recession and Pre-1990**
- **Recession and Post-1990**
- **Non-Recession and Post-1990**

Response Difference: Recession and Post-1990 Vs. Recession and Pre-1990

R response to Bus Cycle Shocks

- Full Sample
- Pre-1990
- Post-1990
- Recession and Pre-1990
- Non-Recession and Pre-1990
- Recession and Post-1990
- Non-Recession and Post-1990

Response Difference: Recession and Post-1990 Vs. Recession and Pre-1990

R response to Bus Cycle Shocks

- **Full Sample**
- **Pre-1990**
- **Post-1990**
- **Recession and Pre-1990**
- **Non-Recession and Pre-1990**
- **Non-Recession and Post-1990**
Summary

- Results are informative as to:
  - Shock based explanation of employment dynamics
  - Shock based explanation of $R&NR$ dynamics
  - When (i.e. state of the economy and type of shocks) routine workers are experience their adjustments.
Backup
## Precision and Recall

<table>
<thead>
<tr>
<th>Predicted</th>
<th>Observed</th>
<th>Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRC</td>
<td>848,364</td>
<td>65.61%</td>
</tr>
<tr>
<td>non-NRC</td>
<td>444,759</td>
<td></td>
</tr>
<tr>
<td>Recall</td>
<td>63.69%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2,380,753</td>
<td>83.12%</td>
</tr>
<tr>
<td></td>
<td>84.26%</td>
<td></td>
</tr>
</tbody>
</table>

- **Precision**: Share of correctly classified within a predicted category.
- **Recall**: The share of true that were picked up by the prediction within a category.
# Precision and Recall by Gender

### Men

<table>
<thead>
<tr>
<th></th>
<th>NRC</th>
<th>Observed non-NRC</th>
<th>Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed NRC</td>
<td>506,002</td>
<td>294,252</td>
<td>63.23%</td>
</tr>
<tr>
<td>Observed non-NRC</td>
<td>242,256</td>
<td>1,213,131</td>
<td>83.35%</td>
</tr>
<tr>
<td>Recall</td>
<td>67.62%</td>
<td>80.48%</td>
<td></td>
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</tbody>
</table>

### Women

<table>
<thead>
<tr>
<th></th>
<th>NRC</th>
<th>Observed non-NRC</th>
<th>Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed NRC</td>
<td>342,362</td>
<td>150,507</td>
<td>69.46%</td>
</tr>
<tr>
<td>Observed non-NRC</td>
<td>241,376</td>
<td>1,167,622</td>
<td>82.87%</td>
</tr>
<tr>
<td>Recall</td>
<td>58.65%</td>
<td>88.58%</td>
<td></td>
</tr>
</tbody>
</table>
Recover clean series for NRC and non-NRC

- Had there been no errors → recover dynamics of the NNRC characteristics.
- With classification errors, use the following two equations to recover clean series:

\[ \hat{x}_{NRC} = S_{NRC|NRC} + S_{NNRC|NRC} \times \hat{x}_{NNRC} \]
\[ \hat{x}_{NNRC} = S_{NRC|NNRC} \times \hat{x}_{NRC} + S_{NNRC|NNRC} \times \hat{x}_{NNRC} \]

where:

<table>
<thead>
<tr>
<th>Classified</th>
<th>NRC</th>
<th>NNRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>True</td>
<td>NRC</td>
<td>( S_{NRC</td>
</tr>
<tr>
<td>NNRC</td>
<td>( S_{NRC</td>
<td>NNRC} )</td>
</tr>
</tbody>
</table>
## Test case 2: NLSY79 cohort of workers in routine occupations

- Results so far informative with respect to what happens to people with identified "Routine characteristics"

- Complementary analysis:
  - Follow a **specific cohort**: what happens to them over time?
NLSY

- Construct weekly employment and job histories
- Count the # of weeks a worker was working in R/NRM/NRC occupation during a baseline period (1985-1989)
- Define a worker of type R (for example) if worked in R occupation for the majority of weeks during the baseline period
- For each year after the baseline calculate the fraction of weeks a person was...
  - working in R/NRM/NRC
  - unemployed
  - not in the labor force
The Evolution of Employment Choices

NLSY: Non-routine cognitive in 1985-1989

---

- **NLF**: Non-routine cognitive
- **E**: Non-routine manual
- **E**: Routine

---


**Ranges**: 0.0 - 0.8

---

**Graph**: 
- **NLF**
- **Unemployment**
- **Non-routine, cognitive**
- **Non-routine manual**
- **Routine**
The Evolution of Employment Choices

The Evolution of Employment Choices

NLSY: Routine in 1985-1989

- NLF
- Unemployment
- E: Non-routine, cognitive
- E: Non-routine manual
- E: Routine
The Evolution of Employment Choices

- In NRM and NRC:
  - Starting age 40 (year 2000): occupation life cycle "stabilizes" and converges

- In R:
  - R to R continues to fall.
  - Fall in R is mainly observed in rise in NLF.
  - For this specific cohort: not so much rise NRM
# The Evolution of Employment Choices

<table>
<thead>
<tr>
<th></th>
<th>To starting occ 1989 → 2000</th>
<th>To starting occ 2000 → 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NRM</strong></td>
<td>-49.5%</td>
<td>-4.9%</td>
</tr>
<tr>
<td><strong>NRC</strong></td>
<td>-15.9%</td>
<td>-7.5%</td>
</tr>
<tr>
<td><strong>R</strong></td>
<td>-18.7%</td>
<td>-16.4%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>To NLF 1989 → 2000</th>
<th>To NLF 2000 → 2015</th>
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</thead>
<tbody>
<tr>
<td><strong>NRM</strong></td>
<td>2.7%</td>
<td>51.9%</td>
</tr>
<tr>
<td><strong>NRC</strong></td>
<td>26.9%</td>
<td>58.1%</td>
</tr>
<tr>
<td><strong>R</strong></td>
<td>23.3%</td>
<td>84.4%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>To NRM 1989 → 2000</th>
<th>To NRM 2000 → 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NRM</strong></td>
<td>-49.5%</td>
<td>-4.9%</td>
</tr>
<tr>
<td><strong>NRC</strong></td>
<td>163%</td>
<td>24.3%</td>
</tr>
<tr>
<td><strong>R</strong></td>
<td>137%</td>
<td>31.5%</td>
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</table>
# The Evolution of Employment Choices (levels)

<table>
<thead>
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<th></th>
<th>To starting occ</th>
<th>To starting occ</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>1989 $\rightarrow$ 2000</td>
<td>2000 $\rightarrow$ 2015</td>
</tr>
<tr>
<td>NRM</td>
<td>$-23.3%$</td>
<td>$-1.1%$</td>
</tr>
<tr>
<td>NRC</td>
<td>$-11.2%$</td>
<td>$-4.5%$</td>
</tr>
<tr>
<td>R</td>
<td>$-11.1%$</td>
<td>$-8.0%$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>To NLF</th>
<th>To NLF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1989 $\rightarrow$ 2000</td>
<td>2000 $\rightarrow$ 2015</td>
</tr>
<tr>
<td>NRM</td>
<td>$0.5%$</td>
<td>$9.5%$</td>
</tr>
<tr>
<td>NRC</td>
<td>$1.9%$</td>
<td>$5.1%$</td>
</tr>
<tr>
<td>R</td>
<td>$2.2%$</td>
<td>$9.9%$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>To NRM</th>
<th>To NRM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1989 $\rightarrow$ 2000</td>
<td>2000 $\rightarrow$ 2015</td>
</tr>
<tr>
<td>NRM</td>
<td>$-23.3%$</td>
<td>$-1.1%$</td>
</tr>
<tr>
<td>NRC</td>
<td>$1.9%$</td>
<td>$0.7%$</td>
</tr>
<tr>
<td>R</td>
<td>$3%$</td>
<td>$1.6%$</td>
</tr>
</tbody>
</table>
The Evolution of Employment Choices: Men

NLSY: Men, Non-routine cognitive in 1985-1989

- NLF
- Unemployment
- E: Non-routine cognitive
- E: Non-routine manual
- E: Routine
The Evolution of Employment Choices: Men

NLSY: Men, Non-routine manual in 1985-1989
The Evolution of Employment Choices: Men

NLSY: Men, Routine in 1985-1989

- NLF
- Unemployment
- E: Non-routine cognitive
- E: Non-routine manual
- E: Routine

Year:
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

Values:
- 0.2
- 0.4
- 0.6
- 0.8

Legend:
- NLF (dashed line)
- Unemployment (dotted line)
- E: Non-routine cognitive (green triangles)
- E: Non-routine manual (orange diamonds)
- E: Routine (solid line)
# The Evolution of Employment Choices: Men

<table>
<thead>
<tr>
<th></th>
<th>To starting occ</th>
<th>To starting occ</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRM</td>
<td>-54.7%</td>
<td>-7.7%</td>
</tr>
<tr>
<td>NRC</td>
<td>-12.5%</td>
<td>-5.5%</td>
</tr>
<tr>
<td>R</td>
<td>-12.9%</td>
<td>-16.5%</td>
</tr>
</tbody>
</table>

|                  | To NLF          | To NLF          |
| NRM              | 33.8%           | 100%            |
| NRC              | 5.6%            | 122%            |
| R                | 46.4%           | 160%            |

|                  | To NRM          | To NRM          |
| NRM              | -54.7%          | -7.7%           |
| NRC              | 55.6%           | 77.0%           |
| R                | 77.4%           | 16.7%           |
The Evolution of Employment Choices (levels): Men

<table>
<thead>
<tr>
<th>To starting occ</th>
<th>To starting occ</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRM</td>
<td>-27.6%</td>
</tr>
<tr>
<td></td>
<td>-1.8%</td>
</tr>
<tr>
<td>NRC</td>
<td>-8.8%</td>
</tr>
<tr>
<td></td>
<td>-3.4%</td>
</tr>
<tr>
<td>R</td>
<td>-8.1%</td>
</tr>
<tr>
<td></td>
<td>-9.0%</td>
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<table>
<thead>
<tr>
<th>To NLF</th>
<th>To NLF</th>
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<tbody>
<tr>
<td>NRM</td>
<td>3.1%</td>
</tr>
<tr>
<td>NRC</td>
<td>0.2%</td>
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<tr>
<td>R</td>
<td>2.4%</td>
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<th>To NRM</th>
</tr>
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<tbody>
<tr>
<td>NRM</td>
<td>-27.6%</td>
</tr>
<tr>
<td>NRC</td>
<td>0.4%</td>
</tr>
<tr>
<td>R</td>
<td>1.5%</td>
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</tbody>
</table>
The Evolution of Employment Choices: Women

NLSY: Women, Non-routine cognitive in 1985-1989
The Evolution of Employment Choices: Women


- NLF
- Unemployment
- E: Non-routine cognitive
- E: Non-routine manual
- E: Routine
The Evolution of Employment Choices: Women

NLSY: Women, Routine in 1985-1989

- NLF
- Unemployment
- E: Non-routine cognitive
- E: Routine
- E: Non-routine manual
## The Evolution of Employment Choices: Women

<table>
<thead>
<tr>
<th></th>
<th>To starting occ</th>
<th>To starting occ</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRM</td>
<td>-46.1%</td>
<td>-3.4%</td>
</tr>
<tr>
<td>NRC</td>
<td>-19.3%</td>
<td>-9.7%</td>
</tr>
<tr>
<td>R</td>
<td>-27.0%</td>
<td>-15.6%</td>
</tr>
</tbody>
</table>

|                  | To NLF         | To NLF         |
| NRM              | -4.8%          | 36.3%          |
| NRC              | 32.9%          | 40.1%          |
| R                | 11.4%          | 39.4%          |

|                  | To NRM         | To NRM         |
| NRM              | -46.1%         | -3.4%          |
| NRC              | 219%           | 10.1%          |
| R                | 195%           | 38.1%          |
# The Evolution of Employment Choices (levels): Women

<table>
<thead>
<tr>
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<th>To starting occ</th>
<th>To starting occ</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRM</td>
<td>-20.8%</td>
<td>-0.8%</td>
</tr>
<tr>
<td>NRC</td>
<td>-13.7%</td>
<td>-5.6%</td>
</tr>
<tr>
<td>R</td>
<td>-15.0%</td>
<td>-6.3%</td>
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<table>
<thead>
<tr>
<th></th>
<th>To NLF</th>
<th>To NLF</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRM</td>
<td>-1.1%</td>
<td>7.9%</td>
</tr>
<tr>
<td>NRC</td>
<td>3.5%</td>
<td>5.7%</td>
</tr>
<tr>
<td>R</td>
<td>1.8%</td>
<td>6.8%</td>
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<thead>
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<th>To NRM</th>
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<tbody>
<tr>
<td>NRM</td>
<td>-20.8%</td>
<td>-0.8%</td>
</tr>
<tr>
<td>NRC</td>
<td>3.3%</td>
<td>0.5%</td>
</tr>
<tr>
<td>R</td>
<td>5.0%</td>
<td>2.9%</td>
</tr>
</tbody>
</table>
Non-NRC type Women

- Employed: R
- Employed: NRM
- Employed: NRC
- Not in Labor Force
- Unemployment Share
- Unemployment Rate
## Women: 2001-2015

<table>
<thead>
<tr>
<th></th>
<th>non-NRC</th>
<th>NRC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) 2001</td>
<td>(2) 2015</td>
</tr>
<tr>
<td>Population Weight</td>
<td>0.58</td>
<td>0.53</td>
</tr>
<tr>
<td>Fraction in R</td>
<td>0.64</td>
<td>0.56</td>
</tr>
<tr>
<td>Fraction in NRM</td>
<td>0.12</td>
<td>0.15</td>
</tr>
<tr>
<td>Fraction in NRC</td>
<td>0.01</td>
<td>~0</td>
</tr>
<tr>
<td>Fraction in NLF</td>
<td>0.19</td>
<td>0.25</td>
</tr>
<tr>
<td>Fraction in Unemployment</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>Unemployment rate</td>
<td>0.05</td>
<td>0.07</td>
</tr>
</tbody>
</table>
## Men: 2001-2015

|                          | non-NRC | NRC |  |  |
|--------------------------|---------|-----|  |  |
|                          |  | (1) | (2) | (3) | (4) |
| Population Weight        | 0.68    | 0.57 | 0.32 | 0.43 |
| Fraction in R            | 0.39    | 0.30 | 0.11 | 0.12 |
| Fraction in NRM          | 0.17    | 0.20 | 0.01 | 0.01 |
| Fraction in NRC          | 0.07    | 0.05 | 0.74 | 0.72 |
| Fraction in NLF          | 0.34    | 0.41 | 0.15 | 0.14 |
| Fraction in Unemployment | 0.03    | 0.04 | 0.01 | 0.02 |
| Unemployment rate        | 0.05    | 0.07 | 0.02 | 0.01 |