SKILLS, OCCUPATIONS, AND WAGE INEQUALITY

Thomas Lemieux, ECON 561, April 2017
Background: The Race Between Supply and Demand

- There is a large literature that tries to explain changes in wage inequality over the last three decades.
- Back in the 1980s and early 1990s the leading explanation was based on Tinbergen’s race between supply and demand of labor for different skill categories.
  - Leading example is Katz and Murphy (1992) where there is a CES aggregate production function.
  - Changes in demand captures by change in technical efficiency parameter (for high-skill workers -> skill-biased technological change).
  - Change in supply related to baby boom, secular changes (slowdown) in educational achievement.
  - Story is that relative demand for high skill workers is slowly going up because of technological change (computerization).
  - Demand has been winning the race since the early 1980s because of the slowdown in the rate of growth in educational achievement, leading to an increase in the skill premium and inequality more generally.
Background: The Race between Supply and Demand

- Goldin and Katz’s book (*The Race Between Education and Technology*, 2010) is a good example of this type of work
- Main thesis is that the U.S. has lost its edge in terms of educational achievement. Particular striking for men.
  - See also Card and Lemieux (2001)
- They present this story as the leading cause of the growth in inequality
- The “solution” is to find a way of increasing educational achievement (subsidizing more higher education, etc.) so that supply starts winning the race again
Background: Some Pitfalls

- Explanations for increasing inequality based on the race between supply and demand are simple and appealing, but there are a numbers of reasons why it is now viewed as a very incomplete part of the inequality story

- Problems I won’t focus on today
  - Supply and demand has a hard time explaining differences across advanced industrialized countries, i.e. why inequality increases in the US and UK but not in France and Japan.
  - Institutional factors (unions, minimum wages, etc.) are an important part of the story in the US and abroad (DiNardo, Fortin, and Lemieux, 1996, Katz and Freeman, 1995)
  - There are problems with “timing”: important dimensions of inequality growth were concentrated in the early 1980s while the race between S&D story should imply a much more steady growth in inequality (Card and DiNardo, 2002, Beaudry and Green, 2005)
  - Doesn’t sounds like the right explanation for what has been happening at the very top end (Piketty and Saez, etc.)
Background: More Pitfalls

- Problems I will focus on today:
  - Since the late 1980, inequality has been growing at the “top end” (e.g. 90-50 gap) but not at the “low end” of the distribution
    - Hard to reconcile with a simple story where wages=skills and an increase in the returns to skill results in an increase in inequality
    - Could try to start differentiating between different skill types at different points of the distribution but this type of exercise becomes quickly very arbitrary
  - At a conceptual level, working with a production function where output depends on skills is a very “reduced form” approach where the type of work people do (occupations and tasks) is completely abstracted from. Cannot help understand questions such as:
    - How does technological change affect the labor market if computers are substitutes for “routine tasks” (Autor, Levy, and Murnane, 2003) that are imperfectly connected to skills?
    - Why are skill groups imperfect substitutes in production?
Plan for today

- Set the stage with stylized facts
- Start with the “canonical model”: production function depends on skills, race between supply and demand
  - Key predictions of the model
  - Where it “fails”
- Propose a more general “task-based” model (Acemoglu and Autor, Handbook of Labor Economics, 2011) where:
  - Production function depends on different tasks/occupations
  - “Efficiency units” of tasks produced depend on skills
- Discuss how it helps better understand secular changes in wage inequality:
  - Acemoglu and Autor: How this help resolves some of the puzzles that the canonical models could not explain
  - Firpo, Fortin, Lemieux: empirical evidence on the role of occupations/tasks
Figure 1

Composition Adjusted College/High-School Log Weekly Wage Ratio, 1963-2008

Log Wage Gap

Figure 3: Education Wage Differentials Relative to High School Graduates, Men
Figure 3a

College/High-School Log Relative Supply, 1963-2008

Log Relative Supply Index

Year

Male 0-9 Yrs Experience
Female 0-9 Yrs Experience
Changes in U.S. Real ($1979) Male Wage Inequality (CPS data)
Changes in U.S. Real ($1979) Female Wage Inequality (CPS data)
Figure 1: Low-end and Top-end Wage Inequality, Men

Wage differential (1973=1)

90-50 gap

50-10 gap
Figure 2: Low-end and Top-end Wage Inequality, Women

Wage differential (1973=1)

- 50-10 gap
- 90-50 gap

- 50-10 gap
- 90-50 gap
Canonical model (from Acemoglu and Autor, 2011)

total supply of high skill and low skill labor in the economy can be written as:

\[ L = \int_{i \in L} l_i \, di \text{ and } H = \int_{i \in H} h_i \, di. \]

The production function for the aggregate economy takes the following constant elasticity of substitution form

\[ Y = \left[ (A_L L)^{\frac{\sigma - 1}{\sigma}} + (A_H H)^{\frac{\sigma - 1}{\sigma}} \right]^{\frac{\sigma}{\sigma - 1}}, \]  \hspace{1cm} (2)

where \( \sigma \in [0, \infty) \) is the elasticity of substitution between high skill and low skill labor, and \( A_L \) and \( A_H \) are factor-augmenting technology terms.\(^{54}\)

Since labor markets are competitive, the low skill unit wage is simply given by the value of marginal product of low skill labor, which is obtained by differentiating (2) as

\[ w_L = \frac{\partial Y}{\partial L} = A_L^{\frac{\sigma - 1}{\sigma}} \left[ A_L^{\frac{\sigma - 1}{\sigma}} + A_H^{\frac{\sigma - 1}{\sigma}} (H/L)^{\frac{\sigma - 1}{\sigma}} \right]^{\frac{1}{\sigma - 1}}. \]  \hspace{1cm} (3)

Similarly, the high skill unit wage is

\[ w_H = \frac{\partial Y}{\partial H} = A_H^{\frac{\sigma - 1}{\sigma}} \left[ A_L^{\frac{\sigma - 1}{\sigma}} (H/L)^{-\frac{\sigma - 1}{\sigma}} + A_H^{\frac{\sigma - 1}{\sigma}} \right]^{\frac{1}{\sigma - 1}}. \]  \hspace{1cm} (4)
Combining (3) and (4), the skill premium—the unit high skill wage divided by the unit low skill wage—is

\[ \omega = \frac{w_H}{w_L} = \left( \frac{A_H}{A_L} \right)^{\frac{\sigma-1}{\sigma}} \left( \frac{H}{L} \right)^{-\frac{1}{\sigma}}. \] (5)

Equation (5) can be rewritten in a more convenient form by taking logs,

\[ \ln \omega = \frac{\sigma - 1}{\sigma} \ln \left( \frac{A_H}{A_L} \right) - \frac{1}{\sigma} \ln \left( \frac{H}{L} \right). \] (6)

Bringing Tinbergen’s education race to the data

\[ \ln \left( \frac{A_{H,t}}{A_{L,t}} \right) = \gamma_0 + \gamma_1 t, \]

\[ \ln \omega_t = \frac{\sigma - 1}{\sigma} \gamma_0 + \frac{\sigma - 1}{\sigma} \gamma_1 t - \frac{1}{\sigma} \ln \left( \frac{H_t}{L_t} \right). \]
Key implications

- The last equation is what Katz and Murphy (1992) did estimate.
- They find that $\sigma = 1.4$
- With more recent data AA find that $\sigma = 2.9$. Reason is that KM estimates overpredict the growth in the skill premium (see next picture) so you need a larger elasticity to fit the more recent data.
- Two important flaws of this model:
  - Technical progress ($A_H$ going up) should have a positive effect on all wages (skilled and unskilled). Cannot explain the decline in real wages for unskilled workers:
  - Cannot explain the U-shape feature of the change in the wage distribution during the 1990s.
Figure 19

Katz-Murphy Prediction Model for the College-High School Wage Gap
More general “task-based” model of the labor market (Acemoglu and Autor)

Cobb-Douglas technology mapping the services of this range of tasks to the final good. In particular,

\[ Y = \exp \left[ \int_0^1 \ln y(i) \, di \right] , \]  

(11)

There are three factors of production, high, medium and low skilled workers. In addition, we will introduce capital or technology (embedded in machines) below. We first assume that there is a fixed, inelastic supply of the three types of workers, \( L, M \) and \( H \). We return to the supply response of different types of skills to changes in technology later in this section.

Each task has the following production function

\[ y(i) = A_L \alpha_L (i) l(i) + A_M \alpha_M (i) m(i) + A_H \alpha_H (i) h(i) + A_K \alpha_K (i) k(i) , \]  

(12)

We impose the following assumption on the structure of comparative advantage throughout:

**Assumption 1** \( \alpha_L (i) / \alpha_M (i) \) and \( \alpha_M (i) / \alpha_H (i) \) are continuously differentiable and strictly decreasing.
More general “task-based” model of the labor market

Factor market clearing requires

\[ \int_0^1 l(i)di \leq L, \int_0^1 m(i)di \leq M \text{ and } \int_0^1 h(i)di \leq H. \]  \hspace{1cm} (13)

**Lemma 1** In any equilibrium there exist \( I_L \) and \( I_H \) such that \( 0 < I_L < I_H < 1 \) and for any \( i < I_L \), \( m(i) = h(i) = 0 \), for any \( i \in (I_L, I_H) \), \( l(i) = h(i) = 0 \), and for any \( i > I_H \), \( l(i) = m(i) = 0 \).

**The law of one price for skills**

\[ w_L = p(i)A_L\alpha_L(i) \text{ for any } i < I_L. \]

\[ w_M = p(i)A_M\alpha_M(i) \text{ for any } I_L < i < I_H. \]

\[ w_H = p(i)A_H\alpha_H(i) \text{ for any } i > I_H. \]
More general “task-based” model of the labor market

Equilibrium wages and inequality

\[
\frac{w_H}{w_M} = \left( \frac{1 - I_H}{I_H - I_L} \right) \left( \frac{H}{M} \right)^{-1}.
\]

Similarly, the wage of medium relative to low skill workers is given by

\[
\frac{w_M}{w_L} = \left( \frac{I_H - I_L}{I_L} \right) \left( \frac{M}{L} \right)^{-1}.
\]

Comparative Statics

Proposition 2  The following comparative static results apply:

1. (The response of task allocation to technology and skill supplies):

\[
\frac{dI_H}{d\ln A_H} = \frac{dI_H}{d\ln H} < 0, \quad \frac{dI_L}{d\ln A_H} = \frac{dI_L}{d\ln H} < 0 \text{ and } \frac{d(I_H - I_L)}{d\ln A_H} = \frac{d(I_H - I_L)}{d\ln H} < 0;
\]

\[
\frac{dI_H}{d\ln A_L} = \frac{dI_H}{d\ln L} > 0, \quad \frac{dI_L}{d\ln A_L} = \frac{dI_L}{d\ln L} > 0 \text{ and } \frac{d(I_H - I_L)}{d\ln A_L} = \frac{d(I_H - I_L)}{d\ln L} < 0;
\]

\[
\frac{dI_H}{d\ln A_M} = \frac{dI_H}{d\ln M} > 0, \quad \frac{dI_L}{d\ln A_M} = \frac{dI_L}{d\ln M} < 0 \text{ and } \frac{d(I_H - I_L)}{d\ln A_M} = \frac{d(I_H - I_L)}{d\ln M} > 0.
\]
More general “task-based” model of the labor market

2. (The response of relative wages to skill supplies):
\[
\frac{d \ln (w_H/w_L)}{d \ln H} < 0, \quad \frac{d \ln (w_H/w_M)}{d \ln H} < 0, \quad \frac{d \ln (w_H/w_L)}{d \ln L} > 0, \quad \frac{d \ln (w_H/w_M)}{d \ln L} > 0, \quad \text{and} \\
\frac{d \ln (w_H/w_L)}{d \ln M} < 0 \quad \text{if and only if} \quad |\beta_L^*(I_L) I_L| \lessgtr |\beta_H^*(I_H)(1 - I_H)|.
\]

3. (The response of wages to factor-augmenting technologies):
\[
\frac{d \ln (w_H/w_L)}{d \ln A_H} > 0, \quad \frac{d \ln (w_M/w_L)}{d \ln A_H} < 0, \quad \frac{d \ln (w_H/w_M)}{d \ln A_H} > 0; \\
\frac{d \ln (w_H/w_L)}{d \ln A_L} < 0, \quad \frac{d \ln (w_M/w_L)}{d \ln A_L} < 0, \quad \frac{d \ln (w_H/w_M)}{d \ln A_L} > 0; \\
\frac{d \ln (w_H/w_M)}{d \ln A_M} > 0, \quad \text{and} \\
\frac{d \ln (w_H/w_L)}{d \ln A_M} < 0 \quad \text{if and only if} \quad |\beta_L^*(I_L) I_L| \lessgtr |\beta_H^*(I_H)(1 - I_H)|.
\]
Introducing “routine-biased” technical change: machines replacing workers

- This can be captured by a large increase in $\alpha_K(i)$ that puts workers out of business for producing task $i$. Remember:

$$y(i) = A_L \alpha_L(i) l(i) + A_M \alpha_M(i) m(i) + A_H \alpha_H(i) h(i) + A_K \alpha_K(i) k(i),$$

- Acemoglu and Autor show that:

**Proposition 4** Suppose we start with an equilibrium characterized by thresholds $[I_L, I_H]$ and technical change implies that the tasks in the range $[I', I''] \subset [I_L, I_H]$ are now performed by machines. Then:

1. $w_H/w_M$ increases;
2. $w_M/w_L$ decreases;
3. $w_H/w_L$ increases if $|\beta'_L(I_L) I_L| < |\beta'_H(I_H) (1 - I_H)|$ and $w_H/w_L$ decreases if $|\beta'_L(I_L) I_L| > |\beta'_H(I_H) (1 - I_H)|$. 
Task-based model: summary

- Acemoglu and Autor solve out for this model and show it helps explain the facts the “canonical model” could not account for.
- As in a Roy model where the choice of occupation/task depends on comparative advantage:
  - Comparative advantage is linked to the α’s in equation (12).
  - For example, high-skill workers are expected to have a comparative advantage in professional/managerial jobs.
- The equilibrium allocation of skills to tasks is characterized by thresholds in the distribution of occupation (I_L and I_H).
- One (unappealing?) feature of the model is that a law of one price holds within each skill group, meaning that all occupations pay the same wage, conditional on skills.
- Having three skill groups enables them to capture the U-shaped feature of changes in the wage distribution.
  - Middle skill workers can be in “routine” occupations that get negatively affected by computerization.
Other features of model with skills and tasks/occupations

- Acemoglu and Autor’s model is highly stylized because it is hard to solve out these types of models.
- For instance, the law of one price doesn’t hold in practice (e.g. Heckman and Scheinkman 1987 and the “unbundling” debate).
- This happens here because # occupations >> # skills, but doesn’t work anymore when the number of skill groups is large (Rosen 1983).
- Leads to a fairly intractable model, but suggests looking explicitly at the role of occupational wage setting in the overall wage distribution.
- Model provides, in principle, an interesting foundation for the elasticity of substitution across skill groups:
  - With a Cobb-Douglas or CES production function in occupations, the elasticity of substitution across skill groups will depend on much they overlap in the occupations space.
  - Provides a “distance-dependent” elasticity of substitution if degree of overlap decreases with some “skill distance” measure.
Taking this to the data

- There is a lot of evidence of polarization in employment by occupation/tasks (e.g. Autor and Dorn, 2013), but little evidence on the sources of polarization in wages.
- In Firpo, Fortin and Lemieux (2013) we try to bring occupations into the kind of decomposition exercises that have been used in the inequality literature.
- We focus on two sources of change in the demand for different occupations:
  - “routine-biased” and other sources of technological change
  - “Offshorability” of occupations
- To operationalize this we use the O*NET data to construct various technological change and offshorability scores for each occupation.
- Assumption is that changes in the demand for these occupations is proxied by these scores.
- Partial equilibrium exercise.
Wage Setting Model

- Worker $i$ produces a task $Y_{jt}$ in occupation $j$ at time $t$:

$$Y_{ij} = \sum_{k=1}^{K} \alpha_{jk}S_{ik},$$

- $S_{ik}$ is a set of $K$ cognitive, non-cognitive, manual skills, etc. Some skills (experience and education) are observed, others are not.

- Wages depend on task produced, task prices $p_{jt}$, year ($\delta_t$) and occupation ($c_j$) effects, and other covariates $Z_{it}$:

$$w_{ijt} = \delta_t + Z_{it}\psi_t + c_j + p_{jt}Y_{ij} \equiv \delta_t + c_j + Z_{it}\psi_t + p_{jt}\sum_{k=1}^{K} \alpha_{jk}S_{ik}.$$
Wage Setting Model

- Since task prices and skills (observed and unobserved) enter multiplicatively, the model implies that changes in task prices affect both the within- and between-occupation components of wage inequality.

- The market value (price) of tasks produced in different occupation change over time because of technology, offshoring, and other factors.

- We will capture this empirically using a “reduced form” task pricing function that links $p_{jt}$ to task content ($T$) measures of occupations. We work with five task content measures that capture the potential for technological change and offshoring in each occupation. The pricing equation is:

$$p_{jt} = \pi_{0t} + \sum_{h=1}^{5} \pi_{ht}T_{jh} + \mu_{jt},$$
Wage Setting Model

- Substituting the task prices in, we get a wage equation where wages depend both on skills and the task content of occupations:

\[ w_{ijt} = \delta_t + c_j + Z_{it}\psi_t + \left[ \pi_{0t} + \sum_{h=1}^{5} \pi_{ht}T_{jh} + \mu_{jt} \right] \sum_{k=1}^{K} \alpha_{jk}S_{ik}. \]

- In this non-linear model, changes in task prices captured by the parameters \( \pi_{ht} \) in the task pricing equation have a complex effect on the wage distribution.
- We will estimate the impact of changes in \( \pi_{ht} \) on wage inequality using a flexible approach (unconditional quantile or “RIF” regressions) where these impacts are allowed to vary at different points of the distribution.
Occupational Tasks

Non-routine vs. Automated vs. Offshored
Occupational Tasks
Using the O*NET

• We combine various “Work Activities” and “Work Context” elements from the O*NET to construct five measures of occupational tasks.

Technology

• 1) **Information Content**: occupations with high information content that are likely to be affected by ICT technologies; they could also be offshored as in Jensen and Kletzer (2007) (JK).

• 2) **Automation**: occupations with high degree of potential/actual automation of jobs and is similar in spirit to the manual routine index of Autor et al. (2003).
Occupational Tasks
Using the O*NET

Non-Offshorability (Negative of Offshorability)

- Designed to capture aspects of job making it unlikely to be offshored
- 3) **Face-to-Face** Contact: if a job requires face-to-face personal interactions with clients and/or co-workers, it is unlikely to be offshored
- 4) **On-Site Job**: reflects the first criteria used by Blinder (B), does the job need to be done at a U.S. work location?
- 5) **Decision-Making**: again, jobs where frequent decision-making is required will be less likely to be offshored, and is similar in spirit to the non-routine analytical index of Autor et al. (2003).
### Occupational Tasks

**O*NET Task Content Indexes**

- Table 1. Average O*NET Indexes by Major Occupation Group

<table>
<thead>
<tr>
<th>O*NET Indexes</th>
<th>Technology</th>
<th>Offshorability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Information</td>
<td>Automation</td>
</tr>
<tr>
<td>Overall Mean</td>
<td>0.6845</td>
<td>0.6871</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.1519</td>
<td>0.1313</td>
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<tr>
<td>Professional, Managerial, Technical</td>
<td>0.8274</td>
<td>0.5857</td>
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<tr>
<td>Clerical, Sales</td>
<td>0.7067</td>
<td>0.7177</td>
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<tr>
<td>Production, Operators</td>
<td>0.6020</td>
<td>0.8205</td>
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<tr>
<td>Primary, Construction, Transport</td>
<td>0.6075</td>
<td>0.6993</td>
</tr>
<tr>
<td>Service</td>
<td>0.5549</td>
<td>0.6437</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Not On-Site</th>
<th>No Face-to-Face</th>
<th>No Decision Making</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Mean</td>
<td>0.4072</td>
<td>0.3171</td>
<td>0.3105</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.2089</td>
<td>0.1062</td>
<td>0.1057</td>
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<tr>
<td>Professional, Managerial, Technical</td>
<td>0.5560</td>
<td>0.2498</td>
<td></td>
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<tr>
<td>Clerical, Sales</td>
<td>0.6095</td>
<td>0.3037</td>
<td>0.3692</td>
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<td>Production, Operators</td>
<td>0.2430</td>
<td>0.4197</td>
<td>0.3608</td>
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<tr>
<td>Primary, Construction, Transport</td>
<td>0.2029</td>
<td>0.3395</td>
<td></td>
</tr>
<tr>
<td>Service</td>
<td>0.4724</td>
<td>0.2762</td>
<td>0.3747</td>
</tr>
</tbody>
</table>

Note: Indexes range between 0.0 and 1.0
Occupational Tasks

O*NET Task Content Indexes and Average Occupational Wages in 2000-02

- Information Content
- Automation
- No Face-to-Face Contact
- No On-Site Job
- No Decision-Making
Decomposition Methodology:
The case of the mean: Oaxaca-Blinder

- We use a decomposition similar in spirit to Oaxaca-Blinder mean decomposition between time period (T=1) and time period (T=0),

\[ \Delta \mu_O = E[Y|T=1] - E[Y|T=0] \]
\[ = E[X|T=1](\beta_1 - \beta_o) + (E[X|T=1] - E[X|T=0]) \beta_o \]
\[ = \Delta^v_S + \Delta^v_X \]

- wage structure effect composition effect

- This is based on a simple regression model where \( Y_{it} = X_{it} \beta_t + \epsilon_{it} \), which implies the following:

\[ E[Y|T=0] = E[X|T=0] \beta_o \], and \( E[Y|T=1] = E[X|T=1] \beta_1 \)

\[ \Rightarrow E[Y|T=1] - E[Y|T=0] = E[X|T=1] \beta_1 - E[X|T=0] \beta_o \]
\[ = (E[X|T=1] \beta_1 - E[X|T=1] \beta_o) + (E[X|T=1] \beta_o - E[X|T=0] \beta_o) \]
\[ = E[X|T=1] (\beta_1 - \beta_o) + (E[X|T=1] - E[X|T=0]) \beta_o \]
Decomposition Methodology:

**Going beyond the mean**

- We use a decomposition similar in spirit to Oaxaca-Blinder mean decomposition between time period \((T=1)\) and time period \((T=0)\),

  \[
  \Delta^{\mu}_O = E [Y|T = 1] - E [Y|T = 0]\]

  \[
  = E [X|T = 1](\beta_1 - \beta_0) + (E [X|T = 1] - E [X|T = 0]) \beta_0
  = \Delta^{\nu}_S + \Delta^{\nu}_X
  \]

  wage structure effect composition effect

- but that works with other distributional statistic \(\nu\) besides the mean

- Consider \(\Delta^{\nu}_O\) the \(\nu\)-**overall change over time** in the distributional statistic \(\nu\):

  \[
  \Delta^{\nu}_O = \nu(F_{Y_1|T=1}) - \nu(F_{Y_0|T=0})
  = [\nu(F_{Y_1|T=1}) - \nu(F_{Y_0|T=1})] + [\nu(F_{Y_0|T=1}) - \nu(F_{Y_0|T=0})]
  = \Delta^{\nu}_S + \Delta^{\nu}_X
  \]

- where \(\Delta^{\nu}_S\) is the wage structure effect and \(\Delta^{\nu}_X\) the composition effect.
Decomposition Methodology:
Going beyond the mean: RIF-Regressions

- For distributional statistics besides the mean, Firpo, Fortin, and Lemieux (2009) suggest estimating the same of regression where the usual outcome variable, $Y$, is replaced by the recentered influence function $\text{RIF}(y; \nu)$.

- The recentering consists of adding back the distributional statistic $\nu$ to the influence function $\text{IF}(y; \nu)$:
  \[
  \text{RIF}(y; \nu) = \nu + \text{IF}(y; \nu)
  \]

- For the mean, the influence function is $\text{IF}(y; \mu) = y - \mu$, so $\text{RIF}(y; \mu) = \mu + (y - \mu) = y$

- For the $\tau$-th quantile of the distribution, $q_\tau$, we have:
  \[
  \text{RIF}(y; \tau) = q_\tau + \text{IF}(Y; q_\tau) = q_\tau + [\tau - 1(Y \leq q_\tau)]/f(q_\tau)
  \]
FFL Methodology:
Using RIF-regressions coefficients

- Because \( v(F) = E_X [E[RIF(y; ν) |X = x]] = E[X|T = t] \gamma^ν \), by analogy with the Oaxaca decomposition, we can use the coefficients \( \gamma^ν \) from a regression of \( RIF(y; ν) \) on \( X \), to write the wage structure and composition effects:

\[
\Delta^ν_S = E [X|T = 1](\gamma^ν_1 - \gamma^ν_0)
\]

and

\[
\Delta^ν_X = (E [X|T = 1] - E [X|T = 0]) \gamma^ν_0
\]

i) the outcome variable, \( Y \), has been replaced by the recentered influence function \( RIF(y; ν) \) of the statistics of interest \( ν \) (Firpo, Fortin, and Lemieux, 2009)
Figure 4. Decomposition of Total Change into Composition and Wage Structure Effects

\[ \Delta v_{O} = \Delta v_{S} + \Delta v_{X} \]
Figure 4. Decomposition of Total Change into Composition and Wage Structure Effects

\[ \Delta \nu_O = \Delta \nu_S + \Delta \nu_X \]
Figure 4. Decomposition of Total Change into Composition and Wage Structure Effects

$$\Delta \nu_O = \Delta \nu_S + \Delta \nu_X$$

C. Change in Log Wages 2003/04 to 2009/10

- Total Change
- Wage Structure
- Composition
Figure 5. Detailed Decomposition of Composition Effects

\[ \Delta^\nu_{X,p} = (E[X_0|T=1] - E[X|T=0]) \gamma^\nu_o \]
Figure 5. Detailed Decomposition of Composition Effects

\[ \Delta^{\nu}_{X,p} = (E[X_0|T=1] - E[X|T=0]) \gamma_{0}^{\nu} \]
Figure 5. Detailed Decomposition of Composition Effects

\[ \Delta^{\nu}X_{p} = (E[X_0|T = 1] - E[X|T = 0]) \gamma^{\nu}_0 \]
Figure 6. Detailed Decomposition of Wage Structure Effects

\[ \Delta^\nu_{S,p} = E[X|T = 1](\gamma_1^\nu - \gamma_{01}^\nu) \]

A. Detailed Wage Structure Effects 1976/78 to 1988/90

Minimum Wage
Figure 6. Detailed Decomposition of Wage Structure Effects

\[ \Delta^\nu_{S,p} = E [X|T = 1](\gamma^\nu_1 - \gamma^\nu_{01}) \]

B. Detailed Wage Structure Effects 1988/90 to 2000/02

Log Wage Change

Quantile

-0.5 0 0.5

-0.5 0 0.5

0 0.2 0.4 0.6 0.8 1

Quantile

Union
Education
Experience
Technology
Offshorability
Figure 6. Detailed Decomposition of Wage Structure Effects

\[ \Delta^\nu_{S,p} = E \left[ X \mid T = 1 \right] (\gamma^\nu - \gamma^\nu_{01}) \]

C. Detailed Wage Structure Effects 2003/04 to 2009/10
Summary

- The 1990s were a unique episode where we observed polarization in wages.
- Technological change (routinization) and offshoring appear to be playing a role in these changes.
- De-unionization is also another factor in these changes.
- By contrast, the evidence on employment polarization (middle jobs disappearing) is much stronger.
  - Holds for several periods in the U.S. (Autor and Dorn, 2013).
  - Widespread across rich countries (Manning Goos, Salomons, 2014).
- It is unclear to what extent the phenomena of routinization and growing inequality are connected.
- Other explanations likely have to be invoked for inequality changes, especially at the top end of the distribution.
Occupational Tasks
Using the O*NET

Technological Change/Offshorability

- Information Content
  - 4.A.1.a.1 Getting Information (JK)
  - 4.A.2.a.2 Processing Information (JK)
  - 4.A.2.a.4 Analyzing Data or Information (JK)
  - 4.A.3.b.1 Interacting With Computers (JK)
  - 4.A.3.b.6 Documenting/Recording Information (JK)

- Automation/Routine
  - 4.C.3.b.2 Degree of Automation
  - 4.C.3.b.7 Importance of Repeating Same Tasks
  - 4.C.3.b.8 Structured versus Unstructured Work (reverse)
  - 4.C.3.d.3 Pace Determined by Speed of Equipment
  - 4.C.2.d.1.i Spend Time Making Repetitive Motions
Occupational Tasks

Using the O*NET

Non-Offshorability

- Face-to-Face Contact
  - 4.C.1.a.2.l Face-to-Face Discussions
  - 4.A.4.a.4 Establishing and Maintaining Interpersonal Relationships (JK, B)
  - 4.A.4.a.5 Assisting and Caring for Others (JK, B)
  - 4.A.4.a.8 Performing for or Working Directly with the Public (JK, B)
  - 4.A.4.b.5 Coaching and Developing Others (B)

- On-Site Job
  - 4.A.1.b.2 Inspecting Equipment, Structures, or Material (JK)
  - 4.A.3.a.2 Handling and Moving Objects
  - 4.A.3.a.3 Controlling Machines and Processes
  - 4.A.3.a.4 Operating Vehicles, Mechanized Devices, or Equipment
  - 4.A.3.b.4 Repairing and Maintaining Mechanical Equipment (*0.5)
  - 4.A.3.b.5 Repairing and Maintaining Electronic Equipment (*0.5)
Non-Offshorability

• Decision-Making
  • 4.A.2.b.1  Making Decisions and Solving Problems (JK)
  • 4.A.2.b.2  Thinking Creatively (JK)
  • 4.A.2.b.4  Developing Objectives and Strategies
  • 4.C.1.c.2  Responsibility for Outcomes and Results
  • 4.C.3.a.2  Frequency of Decision Making
Occupational Tasks

Using the O*NET

- Examples of Work Activities for O*NET Occupations

- Sales Managers (11-2022.00)
  - 11-2022.00 4.A.2.b.2 Thinking Creatively IM 3.95 LV 4.25
  - 11-2022.00 4.A.3.b.1 Interacting With Computers IM 3.80 LV 3.60
  - 11-2022.00 4.A.4.a.5 Assisting and Caring for Others IM 2.25 LV 2.30

- Computer Programmers (15-1021)
  - 15-1021.00 4.A.2.b.2 Thinking Creatively IM 3.11 LV 4.01
  - 15-1021.00 4.A.4.a.5 Assisting and Caring for Others IM 2.86 LV 3.21
### Occupational Tasks Using the O*NET

#### Examples of Work Context for O*Net Occupation

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<tr>
<th>4.C.3.b.8 Structured versus Unstructured Work</th>
<th>Sales Managers</th>
<th>Computer Programmers</th>
<th>Computer Engineers</th>
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<td>11-2022.00</td>
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<td>15-1032.00</td>
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<tr>
<td>N/A</td>
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<td>3.99</td>
<td>4.57</td>
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<td>No freedom</td>
<td>0</td>
<td>0.8</td>
<td>1.52</td>
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<tr>
<td>Very little freedom</td>
<td>4.76</td>
<td>1.12</td>
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<tr>
<td>Limited freedom</td>
<td>0</td>
<td>1.11</td>
<td>0.21</td>
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<tr>
<td>Some freedom</td>
<td>52.38</td>
<td>91.87</td>
<td>35.39</td>
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<tr>
<td>A lot of freedom</td>
<td>42.86</td>
<td>5.09</td>
<td>62.7</td>
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