INEQUALITY, TECHNOLOGY & TRADE: 21st CENTURY EVIDENCE

John Van Reenen
London School of Economics

ADAM SMITH LECTURE JUNE 2010
OUTLINE

1. Recent trends in Wages and Skills
   ─ Wage inequality
   ─ Skills
   ─ Polarization
   ─ Extreme inequality

2. A framework for understanding the changes

3. Extensions to the canonical model
   ─ Polarization and Technology
   ─ Trade Redux: Trade-induced technical change
   ─ Organizational Change

4. Policy and future research
US MALE WAGE INEQUALITY, 1937-2005

UK 90-10 LOG WEEKLY EARNINGS RATIOS, FULL-TIME, 1970-2009

Notes: UK data, 1968-96 (NES) 1997-2009 (ASHE);
Source: Machin and Van Reenen (2010):
CHANGE IN MALE WAGE INEQUALITY (90-10) ACROSS OECD COUNTRIES IN THE 1980s

Source: Machin and Van Reenen (2010), OECD
CHANGE IN MALE WAGE INEQUALITY (90-10) ACROSS OECD COUNTRIES IN THE 1990’s & 2000’s

Source: Machin and Van Reenen (2010), OECD
Note: Netherlands has a break in series in 1993
SKILL DIFFERENTIALS

• Education/skill differentials in wages are an important part of the reason for increased inequality
COLLEGE DEGREE VS. HIGH SCHOOL DIPLOMA
WEEKLY WAGE RATIO (COMPOSITION ADJUSTED) 1963-2008, US, ALL WORKERS

Source: Acemoglu & Autor (2010), March CPS, log(weekly wages) for full-time full year workers.
Notes: Series is adjusted for experience, race and gender (not unobservables).
COLLEGE DEGREE VS. NO COLLEGE FULL TIME WAGE RATIO (COMPOSITION ADJUSTED) 1980-2004, ALL WORKERS, UK

Source: Machin and Van Reenen (2010), GHS & LFS
Notes: Series is adjusted for experience and gender
SKILL DIFFERENTIALS

• Education/skill differentials in wages are an important part of the reason for increased inequality

• But not the whole story:
  – Some within group inequality growth (e.g. Lemieux, 2006). Related to increase in firm productivity dispersion (Faggio, Van Reenen & Salvanes, 2010)
LIKE WAGES, A BIG INCREASE IN DISPERSION OF WITHIN SECTOR PRODUCTIVITY ACROSS UK FIRMS

Productivity dispersion in manufacturing and private services
FAME data 1984-2001

Source: Faggio, Van Reenen & Salvanes (2010)
SKILL DIFFERENTIALS

• Education/skill differentials in wages are an important part of the reason for increased inequality

• But not the whole story:
  – Some within group inequality growth (e.g. Lemieux, 2006). Related to increase in firm productivity dispersion (Faggio, Van Reenen & Salvanes, 2010)
  – Increase in transitory component of earnings shocks (Blundell & Preston, 1998; Meghir & Pistaferri, 2010)
  – Recent evidence on “polarization”….
DIVERGENCE OF UPPER HALF (90-50 LOG HOURLY WAGE) & LOWER HALF (50-10) INEQUALITY, 1975-2005, US

Note: US CPS MORG; Source: Goldin and Katz (2010)
DIVERGENCE OF UPPER (90-50 LOG EARNINGS) & LOWER HALF (50-10) INEQUALITY, FULL-TIME MEN, 1970-2009, UK

Source: Machin and Van Reenen (2010)
FROM MONOTONIC WIDENING TO POLARISATION? US

Source: Autor, Katz & Kearney (2008)
LOVELY AND LOUSY JOBS: EMPLOYMENT SHARE GROWTH 1979-2008 BY JOB QUALITY (OCCUPATIONAL WAGE), UK

Source: Mieske (2009), updates Goos and Manning (2007), % changes for entire period
CHANGE IN EMPLOYMENT SHARES BY OCCUPATION IN 16 EU COUNTRIES, OCCUPATIONS GROUPED BY WAGE TERCILE 1993-2006

TOP 1% SHARE OF ALL INCOME: ENGLISH SPEAKING COUNTRIES, 1910-2007

OUTLINE

1. Recent trends in Wages and Skills

2. A framework for understanding the changes

3. Polarization and Technology

4. Trade Redux: Trade-induced technical change

5. Organizational Change

6. Policy and future research
Relative Wage = \( \frac{W}{W} \)
High vs. Low skill

\( \frac{W}{W} \)

Relative Employment = \( \frac{N}{N} \)
High vs. Low skill

\( \frac{N}{N} \)
THE CANONICAL MODEL: SHIFT IN RELATIVE SUPPLY.....

Relative Wage = \( \frac{W_H}{W_L} \)

Relative Employment = \( \frac{N_H}{N_L} \)

\[
\text{Relative Wage} = \left( \frac{W_H}{W_L} \right)^1 \quad \left( \frac{W_H}{W_L} \right)^2 \\
\text{Relative Employment} = \left( \frac{N_H}{N_L} \right)^1 \quad \left( \frac{N_H}{N_L} \right)^2
\]
THE CANONICAL MODEL: SHIFT IN RELATIVE SUPPLY NEEDS
SHIFT IN RELATIVE DEMAND TO RATIONALIZE INEQUALITY

Relative Wage = \( \frac{W_H}{W_L} \)

Relative Employment = \( \frac{N_H}{N_L} \)

\[ \begin{align*}
(W_H/W_L)^3 \\
(W_H/W_L)^1 \\
(W_H/W_L)^2
\end{align*} \]
THE CANONICAL MODEL: DETAILS

\[ Y = \left[ \lambda N_H^{\frac{\sigma-1}{\sigma}} + (1 - \lambda) N_L^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \]

CES Production Function
skilled \( N_H \) and unskilled labor \( N_L \)

Competitive labor market at wages \( W_H \) and \( W_L \)
THE CANONICAL MODEL: DETAILS

\[ Y = \left[ \lambda N_H^{\frac{\sigma-1}{\sigma}} + (1 - \lambda) N_L^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \]

CES Production Function
skilled \( N_H \) and unskilled labor \( N_L \)

Competitive labor market at wages \( W_H \) and \( W_L \)

\[ \ln \left( \frac{W_H}{W_L} \right) = \ln \left( \frac{\lambda}{1 - \lambda} \right) - \frac{1}{\sigma} \ln \left( \frac{N_H}{N_L} \right) \]

Combine First Order Conditions
THE CANONICAL MODEL: DETAILS

\[ Y = \left[ \lambda N_H^{\frac{\sigma-1}{\sigma}} + (1-\lambda) N_L^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \]

CES Production Function
skilled N \( H \) and unskilled labor N \( L \)

Competitive labor market at wages
\( W_H \) and \( W_L \)

Combine First Order Conditions

\[ \ln \left( \frac{W_H}{W_L} \right) = \ln \left( \frac{\lambda}{1-\lambda} \right) - \frac{1}{\sigma} \ln \left( \frac{N_H}{N_L} \right) \]

"Tinbergen" assumption yields Katz-Murphy (1992): Substitution elasticity
~1.4 & trend 3.3% p.a.
WHAT CAUSES SHIFT IN RELATIVE DEMAND?

• Trade with developing countries? Discuss later.

• **Skill Biased Technical Change (SBTC)**
  – Technology measures (ICT, R&D) strongly correlated with demand growth for more skilled workers
  – **US**: Berman, Bound & Griliches (1994); Autor, Katz & Krueger (1998)

• But SBTC is a long-run force through much of Twentieth Century (Goldin & Katz, 2008). Tinbergen’s (1974) “Race between technology & education”

• The post 1980 US increase in skill premium related to a **deceleration** of the growth of education (Card & Lemieux, 2001, cohorts), not an **acceleration** in SBTC
MEAN YEARS OF SCHOOLING BY BIRTH COHORT

Source: Goldin & Katz (2010), IPUMs, MORG
PROBLEMS WITH CANONICAL MODEL

• Does a reasonable job at accounting for trends in skill premium. But....
1. Polarization/“non-monotonicity” (task-based models)
2. Is technology really exogenous? (e.g. Trade-induced technical change; supply-induced demand)
3. What is firm-level mechanism through which ICT effects skill demand? Organizational change (e.g. Caroli & Van Reenen, 2001; Bartel et al, 2007; Bloom et al, 2009)
4. Cross country differences (role of labor institutions)
5. Falls in real wages for less skilled in US (Autor & Acemoglu, 2010)
OUTLINE

1. Recent trends in Wages and Skills

2. A framework for understanding the changes

3. Polarization and Technology

4. Trade Redux: Trade-induced technical change

5. Organizational Change

6. Policy and future research
POLARIZATION AND THE EFFECT OF ICT (INFORMATION AND COMMUNICATION TECHNOLOGY) ON TASKS

• Extension of technological explanation for changing skill demand. Developed to explain “polarization”: middle skilled group losing demand to both high and low skilled

• Nordhaus (2007) labor cost of performing a standardized set of computational tasks fell by at least 1.7 trillion fold 1850-2006, the bulk of this in last 30 years

• Routinization is the key
ICT AND TASK-BASED DEMAND (E.G. ROBO-ONE ANNUAL ROBOT COMPETITION IN TOKYO)
EXAMPLES OF “AMAZING” THINGS ROBOTS CAN DO

• [http://www.youtube.com/watch?v=CsS1jnIxf4s&feature=related](http://www.youtube.com/watch?v=CsS1jnIxf4s&feature=related)
• Osaka Robocup tournament

Robert Green, England goalkeeper whose blunder let in US equalizer in World Cup last Saturday
### A TAXONOMY OF TASKS: CLASSIC

<table>
<thead>
<tr>
<th>Task type</th>
<th>Task description</th>
<th>Example of occupations</th>
<th>Effect of ICT Education Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td>Rules based; repetitive; procedural</td>
<td>Assembly line workers;</td>
<td>Direct substitution</td>
</tr>
<tr>
<td>Manual</td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Non-Routine</td>
<td>Abstract problem solving; mental</td>
<td>Managers; doctors; lawyers; scientists</td>
<td>Strongly complementary</td>
</tr>
<tr>
<td>Non-</td>
<td>flexibility</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Routine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A TAXONOMY OF TASKS: NUANCED

<table>
<thead>
<tr>
<th>Task type</th>
<th>Task description</th>
<th>Example of occupations</th>
<th>Effect of ICT Education Levels</th>
<th>Education Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine Manual</td>
<td>Rules based; repetitive; procedural</td>
<td>Assembly line workers;</td>
<td>Direct substitution</td>
<td>Low</td>
</tr>
<tr>
<td>Non-Manual</td>
<td>Clerical; Book-keepers</td>
<td>Managers; doctors; lawyers; scientists</td>
<td>Direct substitution</td>
<td>Middle</td>
</tr>
<tr>
<td>Non-Routine Non-Manual Manual</td>
<td>Abstract problem solving (analytic); mental flexibility</td>
<td>Maids/Janitors; security guards; waiters; drivers</td>
<td>Strongly complementary</td>
<td>High</td>
</tr>
<tr>
<td>Manual</td>
<td>Environmental adaptability; Interpersonal adaptability</td>
<td>Maids/Janitors; security guards; waiters; drivers</td>
<td>Broadly Neutral</td>
<td>Low</td>
</tr>
</tbody>
</table>
POLARIZATION AND THE EFFECT OF ICT (INFORMATION AND COMMUNICATION TECHNOLOGY) ON TASKS

• Indirect Evidence:
  – Goos and Manning (2007). UK
  – Goos, Manning and Salomons (2009). Other OECD
  – Firpo, Fortin & Lemieux (2009)

• Direct Evidence:
  – Autor and Dorn (2010)
  – Michaels, Natraj & Van Reenen (2010)
IMPLICATIONS OF ICT AND TASK-BASED DEMAND

• ICT (“computers”) a substitute for routine tasks, complements analytical tasks, but is neutral wrt to non-routine manual tasks

• Implies that technology
  – increases demand for most educated (analytical)
  – reduces demand for middle educated (routine non-manual),
  – little effect on the least educated (now, manual non-routine)
DATA (EU-KLEMS)

• Industry (~SIC3) by OECD country (11), 1980-2004 (Jorgenson et al, 2008; Timmer et al, 2008)
• Based on aggregation of Census Bureau production data matched with other sources (e.g. CPS, LFS)
  – ICT capital: depreciated past investments on hardware, software & communication equipment
• Education broken down into three groups
  – **High** (e.g. College degree or above)
  – **Middle** (e.g. High school grads, some college)
  – **Low** (e.g. High school drop outs)
• Since division of middle/low is hardest, important to control for country fixed effects
• Demand measured by wage bill share of a skill group
CROSS COUNTRY VARIATION IN GROWTH OF COLLEGE WAGE BILL SHARE AND ICT INTENSITY, 1980-2004

Note: Figure plots the growth of high, medium and low-skilled college wage bill shares against the growth of ICT intensity (ICT/VA) for 11 OECD countries (see Table 1). Lines show regressions of the growth of each wage bill share against growth of ICT intensity.
Note: Figure plots the growth from 1980-2004 of high-skilled wage bill shares against the growth of ICT intensity (ICT/VA), by industry, averaged across countries. Lines show fitted values from regressions weighted by the cross-country average of each industry’s share in 1980 employment (solid line for entire economy, dashed line for non-trade industries only).
CROSS INDUSTRY GROWTH IN COLLEGE WAGE BILL SHARE & ICT INTENSITY, AVERAGE ACROSS COUNTRIES, 1980-2004, TRADED SECTORS ONLY

Note: Figure plots the growth from 1980-2004 of high-skilled wage bill shares against the growth of ICT intensity (ICT/VA), by industry, averaged across countries. Lines show fitted values from regressions weighted by the cross-country average of each industry’s share in 1980 employment.
CROSS INDUSTRY GROWTH IN MEDIUM EDUCATED WAGE BILL SHARE & ICT INTENSITY, AVERAGE ACROSS 11 COUNTRIES, 1980-2004, ALL SECTORS

Note: Figure plots the growth from 1980-2004 of medium-skilled wage bill shares against the growth of ICT intensity (ICT/VA), by industry, averaged across countries. Lines show fitted values from regressions weighted by the cross-country average of each industry’s share in 1980 employment (solid line for entire economy, dashed line for non-trade industries only).
CROSS INDUSTRY GROWTH IN MEDIUM EDUCATED WAGE BILL SHARE & ICT INTENSITY, AVERAGE ACROSS 11 COUNTRIES, 1980-2004, TRADED SECTORS

Figure 4B: Growth of Medium-Skilled Share Traded Industries Only

COUNTRIES, 1980-2004, TRADED SECTORS

Note: Figure plots the growth from 1980-2004 of medium-skilled wage bill shares against the growth of ICT intensity (ICT/VA), by industry, averaged across countries. Lines show fitted values from regressions weighted by the cross-country average of each industry’s share in 1980 employment.
CROSS INDUSTRY GROWTH IN **LOW EDUCATED WAGE BILL SHARE & ICT INTENSITY**, AVERAGE ACROSS 11 COUNTRIES, 1980-2004, ALL SECTORS

*Note:* Figure plots the growth from 1980-2004 of low-skilled wage bill shares against the growth of ICT intensity (ICT/VA), by industry, averaged across countries. Lines show fitted values from regressions weighted by the cross-country average of each industry’s share in 1980 employment (solid line for entire economy, dashed line for non-trade industries only).
Figure 5B: Growth of Low-Skilled Share Traded Industries Only

Note: Figure plots the growth from 1980-2004 of low-skilled wage bill shares against the growth of ICT intensity (ICT/VA), by industry, averaged across countries. Lines show fitted values from regressions weighted by the cross-country average of each industry’s share in 1980 employment.
EMPIRICAL MODEL

Representative firm in an industry’s cost function, \( CV(.) \)

\[
CV (W^H, W^M, W^L ; C, K, Q)
\]

\( H \) = highly educated
\( M \) = middle educated
\( L \) = low educated

\( C \) = ICT capital
\( K \) = non-ICT capital
\( Q \) = value added

Assume \( CV(.) \) translog. By Shephard’s Lemma wage bill \( SHARE \) of skill group \( S \) in total variable costs (the wage bill) is:

\[
SHARE^S = \phi_{HS} \ln(W^H / W^L) + \phi_{MS} \ln(W^M / W^L) \\
+ \alpha_{CS} \ln(C / Q) + \alpha_{KS} \ln(K / Q) + \alpha_{YS} \ln(Q)
\]
EMPIRICAL MODEL

• Estimate in 25 year differences
• National labor markets so relative wages controlled for by country*year dummies
• 3 equations education group S, industry i, country j

\[ \Delta SHARE_{ijt}^S = c_j^S + \beta_1^S \Delta (C/Q)_{ijt} + \beta_2^S \Delta (K/Q)_{ijt} + \beta_3^S \Delta \ln(Q)_{ijt} + u_{ijt} \]

ICT capital  Non-ICT capital  Value added

Hypotheses:
• Coefficient on ICT capital intensity positive for high skilled?
• Coefficient on ICT capital intensity negative for middle skilled?

Potential instrumental variables:
• Initial level of ICT in industry in US in base year (1980)
• Initial share of routine tasks in US in base year (1980), DOT, O*NET, Autor and Dorn (2009)
### GROWTH OF WAGE BILL SHARES, 1980-2004 (ALL SECTORS)

**A. Dependent variable: ΔCollege Wage Bill Share**

<table>
<thead>
<tr>
<th>Δ ((ICT capital) / (Value Added))</th>
<th>72.29</th>
<th>64.56</th>
<th>46.92</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(18.28)</td>
<td>(17.31)</td>
<td>(14.94)</td>
</tr>
<tr>
<td>Intercept</td>
<td>10.02</td>
<td>8.69</td>
<td>2.22</td>
</tr>
<tr>
<td></td>
<td>(0.57)</td>
<td>(0.63)</td>
<td>(1.67)</td>
</tr>
</tbody>
</table>

| Country fixed effects (11)       | No    | No    | No    | Yes   |
| Control for Δ(non-ICT capital/value added) | No    | No    | Yes   | Yes   |
| Control for Δln(value added)     | No    | No    | Yes   | Yes   |

**Note:** Estimated by OLS in long differences (robust standard errors) 208 observations  
**Source:** Michaels, Natraj & Van Reenen (2010)
### GROWTH OF WAGE BILL SHARES, 1980-2004 (ALL SECTORS)

#### A. Dependent variable: \( \Delta \) College Wage Bill Share

<table>
<thead>
<tr>
<th>( \Delta (\text{ICT capital}) / \text{(Value Added)} )</th>
<th>72.29</th>
<th>64.56</th>
<th>46.92</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(18.28)</td>
<td>(17.31)</td>
<td>(14.94)</td>
</tr>
<tr>
<td>Intercept</td>
<td>10.02</td>
<td>8.69</td>
<td>2.22</td>
</tr>
<tr>
<td></td>
<td>(0.57)</td>
<td>(0.63)</td>
<td>(1.67)</td>
</tr>
</tbody>
</table>

#### B. Dependent variable: \( \Delta \) Medium-skilled Wage Bill Share

<table>
<thead>
<tr>
<th>( \Delta (\text{ICT capital}) / \text{(Value Added)} )</th>
<th>-100.78</th>
<th>-77.76</th>
<th>-64.52</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(30.21)</td>
<td>(25.44)</td>
<td>(20.24)</td>
</tr>
<tr>
<td>Intercept</td>
<td>8.73</td>
<td>10.59</td>
<td>27.24</td>
</tr>
<tr>
<td></td>
<td>(1.29)</td>
<td>(1.49)</td>
<td>(3.73)</td>
</tr>
</tbody>
</table>

#### C. Dependent variable: \( \Delta \) Low-skilled Wage Bill Share

<table>
<thead>
<tr>
<th>( \Delta (\text{ICT capital}) / \text{(Value Added)} )</th>
<th>28.55</th>
<th>13.21</th>
<th>17.71</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(27.34)</td>
<td>(25.66)</td>
<td>(16.41)</td>
</tr>
<tr>
<td>Intercept</td>
<td>-18.74</td>
<td>-19.26</td>
<td>-29.5</td>
</tr>
<tr>
<td></td>
<td>(1.12)</td>
<td>(1.31)</td>
<td>(3.27)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country fixed effects</th>
<th>No</th>
<th>No</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control for ( \Delta (\text{non-ICT capital/value added}) )</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Control for ( \Delta \ln(\text{value added}) )</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Note:** Estimated by OLS in long differences (robust standard errors) 208 observations

**Source:** Michaels, Natraj & Van Reenen (2010)
SUMMARY ON ICT AND TASK-BASED DEMAND

- ICT story plausible: substitution away from middle towards top (& bottom)

- Alternative stories:
  - Consumption of the better off supports (local) demand for low skilled (e.g. Mazzolari & Ragusa, 2008)
  - Household labor supply (e.g. Ngai-Pissarides, 2007)
  - Trade and offshoring (next...)

- Short on evidence
OUTLINE

1. Recent trends in Wages and Skills

2. A framework for understanding the changes

3. Polarization and Technology

4. Trade Redux: Trade-induced technical change

5. Organizational Change

6. Policy and future research
TRADE AS A CAUSE OF RISING SKILL DEMAND

• Early analyses of demand shock against unskilled pointed to trade with developing countries (e.g. Wood, 1994). Standard Heckscher-Ohlin/Stolper-Samuelson

• Consensus emerged that trade not the culprit
  – Aggregate growth of skill shares mainly *within* industries (indeed, within plants)
  – No clear fall in skill premium in developing countries
  – Magnitudes of trade changes too small to account for changes (both in GE models & factor content analysis)
  – Trade variables dominated by technology in “horse race”
TRADE AND TECHNOLOGY (TRADED SECTORS ONLY). NO TRADE EFFECT AFTER CONTROLLING FOR TECHNOLOGY

Dependent variable: $\Delta$College Wage Bill Share, 2004-1980

<table>
<thead>
<tr>
<th>Sample</th>
<th>All</th>
<th>All</th>
<th>Drop Austria &amp; Spain (no R&amp;D data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta ((\text{Imports}+ \text{Exports}) / (\text{Value Added}))$</td>
<td>0.71 (0.25)</td>
<td>0.59 (0.15)</td>
<td>0.50 (0.19)</td>
</tr>
<tr>
<td>$\Delta ((\text{ICT capital}) / (\text{Value Added}))$</td>
<td>107.61 (31.70)</td>
<td>94.25 (34.07)</td>
<td>73.59 (31.41)</td>
</tr>
<tr>
<td>1980 (Research and Development Expenditure/ Value Added)</td>
<td>34.18 (18.23)</td>
<td>28.04 (17.59)</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>84</td>
<td>84</td>
<td>65</td>
</tr>
</tbody>
</table>

Note: Estimated by OLS in long differences (robust standard errors), all columns include: country dummies, non-ICT capital/value added, growth of value added

Source: Michaels, Natraj & Van Reenen (2010)
TWO LIMITATIONS OF THE CONSENSUS THAT TRADE DID NOT MATTER

1. Studies mainly conducted using data through early 1990s – before rise of China (over)
CHINA’S SHARE OF ALL EU AND US IMPORTS

We use data from 1996-2007

No trade-effect on inequality consensus formed using data from 1970s to early 1990s

Source: UN Comtrade data
TWO LIMITATIONS OF THE CONSENSUS THAT TRADE DID NOT MATTER

1. Studies mainly conducted using data through early 1990s – before rise of China (over)

2. Technology assumed exogenous (e.g. Acemoglu, 1999, 2002, 2008). In particular trade could induce faster technical change
TRADE- INDUCED TECHNICAL CHANGE
(Bloom, Draca & Van Reenen, 2010)

• Examine impact of growth of Chinese import competition 1995-2007 on technical change in 12 European countries (~0.5m firms)

• Technical change within firm increases when Chinese import competition rises
  – Patents & citations (European Patent Office)
  – R&D (BVD Osiris)
  – ICT adoption (Harte-Hanks)
  – TFP (BVD Amadeus)

• Reallocation
  – Chinese import competition causes low-tech firms to shrink and exit

• Both forces imply faster technology upgrading
## GROWTH OF CHINESE IMPORTS INCREASE TECHNICAL CHANGE

<table>
<thead>
<tr>
<th>Dependent Variable:</th>
<th>( \Delta \ln(\text{IT/N}) )</th>
<th>( \Delta \ln(\text{PATENTS}) )</th>
<th>( \Delta \ln(\text{R&amp;D}) )</th>
<th>( \Delta \ln(\text{TFP}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Chinese Imports</td>
<td>0.354***</td>
<td>0.610***</td>
<td>2.145*</td>
<td>0.447***</td>
</tr>
<tr>
<td>( \Delta \left( M_{j,k}^{\text{China}} / M_{j,k}^{\text{World}} \right) )</td>
<td>(0.120)</td>
<td>(0.182)</td>
<td>(1.186)</td>
<td>(0.132)</td>
</tr>
</tbody>
</table>

**Source:** Draca, Bloom and Van Reenen (2010)

**Note:** 5 year differences. Industry (SIC4) by country (11) regressions

Industry coefficients almost double the firm/plant coefficients, implies reallocation effect about the same size as the within effect.
DEALING WITH ENDOGENEITY OF TRADE USING POLICY EXPERIMENT: CHINA’S ENTRY INTO WTO IN 2001

• The Multi Fiber Agreement (1974) restricted apparel and textile exports from developing countries

• The MFA was negotiated into GATT (WTO) as part of the Uruguay Round in 1994, with a 4 phase abolition 1995-2005

• When China entered the WTO in Dec 2001 it gained access to this phased abolition, occurring between 2001 and 2005

• When Chinese products came off quota there was huge surge of imports into EU and US

• Because there was some (endogenous) re-introduction of some quotas in 2006 we use baseline quotas in 2000
# USING QUOTA REMOVAL INSTRUMENTAL VARIABLE (PLANT-LEVEL DATA)

<table>
<thead>
<tr>
<th>Method</th>
<th>$\Delta \ln(IT/N)$</th>
<th>$\Delta$ Chinese Imports</th>
<th>$\Delta \ln(IT/N)$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>First Stage</td>
<td>IV</td>
</tr>
<tr>
<td>$\Delta$ Chinese Imports</td>
<td>1.284*** (0.172)</td>
<td></td>
<td>1.851*** (0.400)</td>
</tr>
<tr>
<td>Quotas removal</td>
<td></td>
<td></td>
<td>0.088*** (0.019)</td>
</tr>
</tbody>
</table>

Sample period: 2005-2000
Number of units: 2,891
industry clusters: 83
Observations: 2,891

Source: Draca, Bloom and Van Reenen (2010)
Notes: plant level data, SE clustered by 4 SIC4, Cty-year and site type dummies included
FINDINGS

• Chinese import shock induces faster technical change within surviving plants
• Also reallocation– low tech plants shrink and exist (with trade models of heterogeneous firms, e.g. Melitz, 2003).
• Combined within & reallocation effects accounts for 15% of technical change 2000-2007 (& ~25% in recent years)
• No effect from high wage countries imports on technology. Consistent with “trapped factor” model of Bloom, Romer and Van Reenen (2009)
• Evidence for effects of offshoring (Feenstra & Hansen, 1999; Garicano & Rossi-Hansberg, 2006) and product switching (Bernard, Scott & Redding, 2009)
  – But neither drive the results
CHINA ASSOCIATED WITH SKILL UPGRADING (WAGE BILL SHARE OF COLLEGE EDUCATED IN UK)

<table>
<thead>
<tr>
<th>Sample</th>
<th>All</th>
<th>All</th>
<th>All</th>
<th>Textiles &amp; Apparel</th>
<th>Textiles &amp; Apparel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>OLS</td>
<td>OLS</td>
<td>OLS</td>
<td>OLS</td>
<td>IV</td>
</tr>
<tr>
<td>Change in Chinese Imports</td>
<td>0.144**</td>
<td>0.099**</td>
<td>0.166***</td>
<td>0.227***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.035)</td>
<td>(0.043)</td>
<td>(0.030)</td>
<td>(0.053)</td>
<td></td>
</tr>
<tr>
<td>Change in IT intensity</td>
<td>0.081**</td>
<td>0.050*</td>
<td>(0.0264)</td>
<td>(0.026)</td>
<td></td>
</tr>
</tbody>
</table>

F-Test in first stage
IT & Chinese imports 0.000  9.21
Observations 204  204  48  48

Source: Draca, Bloom and Van Reenen (2010)
Notes: SE are clustered by SIC3 industries; 2006-1999, UK LFS data, IV is height of quota pre-WTO; all columns control for year dummies, regressions weighted by industry employment in 1999
1. Recent trends in Wages and Skills
2. A framework for understanding the changes
3. Polarization and Technology
4. Trade Redux: Trade-induced technical change
5. Organizational Change
6. Policy and future research
ORGANISATIONAL CHANGE (1/2)

• Case study and econometric evidence that ICT requires organizational and managerial change to raise productivity
  – Bresnahan, Brynjolfsson and Hitt (2002); Bloom, Sadun and Van Reenen (2007)
• It is these organizational changes that effect the position of workers, their wages and skills
• Example: Intensive use of ICT often involves significant decentralization & delayering
  – Caroli & Van Reenen (2001) evidence for “skill biased organizational change” in British and French plants
  – Bartel, Ichinowski & Shaw (2007) on US valve manufacturers
ORGANISATIONAL CHANGE (2/2)

- Economics of organization. Garicano (2000), firm as a “knowledge hierarchy”. Falls in IT (info acquisition costs) causes decentralization & increases demand for skills.

- Bloom, Sadun, Garicano and Van Reenen (2010). Collect data inside ~4,000 firms in 12 countries. Find support for IT increasing decentralization.

OUTLINE

1. Recent trends in Wages and Skills

2. A framework for understanding the changes

3. Polarization and Technology

4. Trade Redux: Trade-induced technical change

5. Organizational Change

6. Policy and future research
SUMMARY

• Wage inequality, especially for top half has risen secularly in US and UK since end of 1970s
• Most other OECD countries also seeing increases in wage inequality, albeit later and slower
• Canonical model: technology creates long-term demand for more skilled workers and supply races to keep up.
• But richer model of task-based technical progress where ICT replaces routine tasks & has non-monotonic effect on skill demand – middle is mainly suffering
• Trade with less developed countries has an indirect effect on skills through inducing faster technical change
POLICY IMPLICATIONS

• Trade has additional welfare effects on innovation in addition to lower prices, etc. Need to smooth transitions for displaced workers & compensate those who lose
• Education & building human capital still main way of addressing problem. Why do more men not go to college?
• But polarization is challenging
  – Improving education so that high school drop outs get high school diploma not enough
  – Middle classes stronger political force than poor. Recession highlights the fact that they are losing out. On one hand, from social planner view less bad that poor are not getting poorer. On other, political economy problems.
RESEARCH IMPLICATIONS ("Do not ask me to write the music of the future")

- Task-based models more complex, but great potential to explain puzzling facts
  - Need for more rigorous testing of these theories

- Trade has subtle effects on labour market, e.g. By influencing technology. Trade & labour literatures are converging around worker and firm heterogeneity.
  - Empirics
  - Adjustment process

- "Inside the firm" - Organizational change & management
THANK YOU!
“A man educated at the expense of much labour and time to any of those employments which require extraordinary dexterity and skill, may be compared to one of those expensive machines. The work which he learns to perform, it must be expected, over and above the usual wages of common labour, will replace to him the whole expense of his education, with at least the ordinary profits of an equally valuable capital.”

Book I, Chapter 10, “Of Wages and Profit in the Different Employments of Labour and Stock” I.10.9
Figure 1: The change in share of all income going to the top 1%, 2-5% and 6-10%

Source: Bell and Van Reenen (2010)
Notes: Figures are computed from the Annual Survey of Hours and Earnings, ONS
## MALE 90-10 WAGE RATIOS ACROSS COUNTRIES, 1970-2008
- UK AND US NOT SUCH OUTLIERS POST 1990

<table>
<thead>
<tr>
<th></th>
<th>1970</th>
<th>1980</th>
<th>1990</th>
<th>Δ</th>
<th>2000</th>
<th>2008</th>
<th>Δ’90s &amp;00’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austral</td>
<td>2.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.7</td>
<td>2.7</td>
<td>0</td>
<td>3.1</td>
<td>3.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Den</td>
<td>-</td>
<td>2.1</td>
<td>2.2</td>
<td>0.1</td>
<td>2.5</td>
<td>2.7&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.5</td>
</tr>
<tr>
<td>Finland</td>
<td>-</td>
<td>2.5</td>
<td>2.5</td>
<td>0</td>
<td>2.4</td>
<td>2.6&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.1</td>
</tr>
<tr>
<td>France</td>
<td>3.7</td>
<td>3.3</td>
<td>3.3</td>
<td>0</td>
<td>3.0</td>
<td>2.9&lt;sup&gt;d&lt;/sup&gt;</td>
<td>-0.4</td>
</tr>
<tr>
<td>Ger</td>
<td>-</td>
<td>2.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.5</td>
<td>0</td>
<td>2.8</td>
<td>2.9&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.4</td>
</tr>
<tr>
<td>Japan</td>
<td>2.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.6</td>
<td>2.8</td>
<td>0.2</td>
<td>2.8</td>
<td>2.9</td>
<td>0.1</td>
</tr>
<tr>
<td>NDL</td>
<td>-</td>
<td>2.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.5</td>
<td>0.2</td>
<td>2.9</td>
<td>2.9&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.4</td>
</tr>
<tr>
<td>NZInd.</td>
<td>-</td>
<td>2.2</td>
<td>2.5</td>
<td>0.3</td>
<td>2.7</td>
<td>3.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Sweden</td>
<td>2.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.1</td>
<td>2.1</td>
<td>0</td>
<td>2.4</td>
<td>2.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.3</td>
</tr>
<tr>
<td>UK</td>
<td>2.7</td>
<td>2.7</td>
<td>3.3</td>
<td>0.6</td>
<td>3.4</td>
<td>3.7</td>
<td>0.4</td>
</tr>
<tr>
<td>US</td>
<td>3.4</td>
<td>3.6</td>
<td>4.4</td>
<td>0.8</td>
<td>4.8</td>
<td>5.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Average</td>
<td>3.05</td>
<td>3.15</td>
<td>3.85</td>
<td>0.2</td>
<td>4.1</td>
<td>4.35</td>
<td>0.35</td>
</tr>
</tbody>
</table>


**Notes:** Data are from different years to the column header for some countries a – 1975; b – 1984; c – 2004; d – 2005; e – 2007.
Figure 6: Overall distributional effects of Labour’s tax benefit policies 1996/97 to 2007/08 compared with price and earnings indexation (percentage change in disposable income)

Figure 2H: Overall distributional effect of tax-benefit policies, 1996-97 to 2007-08, compared to price and earnings indexation (percentage change in disposable income)

Source: Softon, Hills and Sutherland (2009), figure 2.5.
Figure 5: Household income, trends in household upper half (90-50) and lower half (50-10) income inequality, 1970-2008

Source: IFS, http://www.ifs.org.uk/bns/bn19figs.zip, as used in Figure 2.13 of NEP (2010)
Table 4: Growth College Ed Wage Bill Share, robustness

<table>
<thead>
<tr>
<th>Estimation Method</th>
<th>OLS (Baseline)</th>
<th>OLS (Initial Conditions)</th>
<th>OLS (Continental EU only)</th>
<th>OLS (US only)</th>
<th>2SLS (drop USA)</th>
<th>2SLS (drop USA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ[(ICT capital) / (Value Added)]</td>
<td>46.92 (14.94)</td>
<td>42.09 (14.66)</td>
<td>50.98 (16.64)</td>
<td>132.84 (52.59)</td>
<td>103.16 (48.82)</td>
<td>65.31 (104.60)</td>
</tr>
<tr>
<td>1980 College wagebill share</td>
<td>0.06 (0.06)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980 Medium wagebill share</td>
<td>0.12 (0.05)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obs.</td>
<td>208</td>
<td>143</td>
<td>27</td>
<td>181</td>
<td>181</td>
<td></td>
</tr>
</tbody>
</table>

Instrumental Variable
- Level of Industry ICT/VA in US in 1980
- Level of Industry share of routine tasks in US in 1980 (DOT)

F-stat for excluded instrument
- 9.6
- 8.3

Note: Estimated by OLS in long differences (robust standard errors), all columns include country dummies, non-ICT capital/value added, growth of value added.
Table 6 – Back of the envelope Magnitudes. Technology accounts for up to 25% of Skill upgrading

<table>
<thead>
<tr>
<th>Sectors</th>
<th>All No Controls, OLS</th>
<th>All Full Controls, OLS</th>
<th>Traded No Controls, OLS</th>
<th>Traded Full Controls, OLS</th>
<th>All No controls, IV</th>
<th>All Full controls, IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ (College wage-bill share)</td>
<td>10.02</td>
<td>10.02</td>
<td>9.37</td>
<td>9.37</td>
<td>10.02</td>
<td>10.02</td>
</tr>
<tr>
<td>Δ ((ICT capital) / (Value Added))</td>
<td>0.018</td>
<td>0.018</td>
<td>0.017</td>
<td>0.017</td>
<td>0.018</td>
<td>0.018</td>
</tr>
<tr>
<td>Coefficient on ICT</td>
<td>72.3</td>
<td>46.9</td>
<td>83.1</td>
<td>75.5</td>
<td>152.3</td>
<td>121.6</td>
</tr>
<tr>
<td>Mean*Coefficient of ICT</td>
<td>1.32</td>
<td>0.86</td>
<td>1.45</td>
<td>1.31</td>
<td>2.78</td>
<td>2.22</td>
</tr>
<tr>
<td>Mean contribution % of ICT</td>
<td>13.16</td>
<td>8.50</td>
<td>15.43</td>
<td>14.03</td>
<td>27.72</td>
<td>22.14</td>
</tr>
<tr>
<td>R&amp;D/Value Added</td>
<td>0.028</td>
<td>0.028</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficient on R&amp;D</td>
<td>52.79</td>
<td>30.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean*Coefficient on R&amp;D</td>
<td>1.49</td>
<td>0.85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean contribution of R&amp;D</td>
<td>15.90</td>
<td>9.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total accounted for by technology measures</td>
<td>13.16</td>
<td>8.50</td>
<td>31.33</td>
<td>23.10</td>
<td>27.72</td>
<td>22.14</td>
</tr>
</tbody>
</table>

Note: IV uses the initial level of US industry ICT as an IV specification
TOP 1% SHARE OF ALL INCOME: NORDIC AND SOUTHERN EUROPEAN COUNTRIES, 1910-2005

Source: Atkinson, Piketty & Saez (2009)
TOP 1% SHARE OF ALL INCOME: JAPAN & MIDDLE EUROPEAN COUNTRIES, 1910-2005

Source: Atkinson, Piketty & Saez (2009)
Real Wage Growth by Education: Full Time Males

Source: Based on March CPS.

WITHIN GROUP INEQUALITY

Panel A: March CPS Full-Time Weekly Earnings, 1963 to 2005

Panel B: CPS MORG Hourly Earnings, 1973 to 2006

U.S. High School Graduation Rate, 1890 to 2004

THE CANONICAL MODEL: DETAILS

\[
Y = \left[ (A_L N_L)^{\sigma-1} \sigma + (A_H N_H)^{\sigma-1} \right]^{\sigma \over \sigma-1}
\]

**CES Production Function**

skilled $N_H$ and unskilled labor $N_L$

Competitive labor market at wages $W_H$ and $W_L$

Combine First Order Conditions

\[
\ln \left( \frac{W_H}{W_L} \right) = \frac{\sigma - 1}{\sigma} \ln \left( \frac{A_H}{A_L} \right) - \frac{1}{\sigma} \ln \left( \frac{N_H}{N_L} \right)
\]

Slope = -0.61

$\sigma_{SU} = 1.64$
UPPER (90-50 LOG EARNINGS) & LOWER HALF (50-10 LOG EARNINGS) INEQUALITY, FULL-TIME WOMEN 1970-2009

Source: Machin (2010)
Middle skilled occupations experience relative falls in jobs,

Source: Goos and Manning (2007)
Percent changes in male and female hourly wages relative to the median

Source: May/ORG CPS data for earnings years 1973-2009. Each year comprises a three-year moving average (e.g. 1974 contains May/ORG data from 1973, 1974, and 1975), with years equally weighted. The real log hourly wage is computed by year for each percentile between the 5th and 95th percentiles. In every year, real log hourly wages are adjusted such that they equal zero at the respective year’s median (50th percentile). The percent change represents the difference in the log wages values (relative to the median) at each percentile between the relevant years.
## GROWTH OF WAGE BILL SHARES, 1980-2004 (ALL SECTORS)

### A. Dependent variable: $\Delta$College Wage Bill Share

$\Delta \left( \frac{\text{ICT capital}}{\text{Value Added}} \right)$

<table>
<thead>
<tr>
<th>Intercept</th>
<th>10.02</th>
<th>(0.57)</th>
</tr>
</thead>
</table>

### B. Dependent variable: $\Delta$Medium-skilled Wage Bill Share

$\Delta \left( \frac{\text{ICT capital}}{\text{Value Added}} \right)$

<table>
<thead>
<tr>
<th>Intercept</th>
<th>8.73</th>
<th>(1.29)</th>
</tr>
</thead>
</table>

### C. Dependent variable: $\Delta$Low-skilled Wage Bill Share

$\Delta \left( \frac{\text{ICT capital}}{\text{Value Added}} \right)$

<table>
<thead>
<tr>
<th>Intercept</th>
<th>-18.74</th>
<th>(1.12)</th>
</tr>
</thead>
</table>

| Country fixed effects (11) | No |
| Control for $\Delta$(non-ICT capital/value added) | No |
| Control for $\Delta\ln$(value added) | No |

**Note:** Estimated by OLS in long differences (robust standard errors) 208 observations

**Source:** Michaels, Natraj & Van Reenen (2010)
Table 4- Cont: IV estimates using changes in EU textile & clothing quotas – Patents and TFP

<table>
<thead>
<tr>
<th>Method</th>
<th>ΔPATENTS</th>
<th>Δ Chinese Imports</th>
<th>ΔPATENTS</th>
<th>Δln(TFP)</th>
<th>Δ Chinese Imports</th>
<th>Δln(TFP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>First Stage</td>
<td>IV</td>
<td>OLS</td>
<td>First Stage</td>
<td>IV</td>
</tr>
<tr>
<td>ΔChinese Imports</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔChinese Imports (t-3)</td>
<td>1.294***</td>
<td>(0.478)</td>
<td>3.933*</td>
<td>0.829***</td>
<td>(0.303)</td>
<td>1.490***</td>
</tr>
<tr>
<td>Quotas removal</td>
<td></td>
<td>0.034***</td>
<td></td>
<td></td>
<td>0.088***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.015)</td>
<td></td>
<td></td>
<td>(0.011)</td>
<td></td>
</tr>
</tbody>
</table>

Sample period: 2005-1999

<table>
<thead>
<tr>
<th>Units</th>
<th>Industry clusters</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,810</td>
<td>81</td>
<td>3,339</td>
</tr>
<tr>
<td>1,810</td>
<td>81</td>
<td>3,339</td>
</tr>
<tr>
<td>12,470</td>
<td>200</td>
<td>21,007</td>
</tr>
</tbody>
</table>

SE clustered by 4 digit industries, Country-year and site type dummies included
CHANGE IN MALE WAGE INEQUALITY (90-10) ACROSS OECD COUNTRIES IN THE 1990’s AND 2000’s
Proportion of low-wage country imports into Europe & US has risen rapidly (China)

Cumulative Log Change in Real Weekly Earnings at the 90th, 50th and 10th Wage Percentiles
1963-2008: Full-Time Full-Year Males and Females

Source: March CPS data for earnings years 1963-2008. For each year, the 10th, median and 90th percentiles of log weekly wages are calculated for full-time, full-year workers.

Source: Acemoglu & Autor (2010)
Cumulative Log Change in Real Weekly Earnings at the 90th, 50th and 10th Wage Percentiles
1963-2008: Full-Time Full-Year Males
CHANGE IN LN(WEEKLY FULL TIME MALE WAGES) 90-10, UK, 1968=0

Source: NFS/ASHF
Detrended Changes in College/High-School Relative Supply and Relative Wages

Source: March CPS data for earnings years 1963-2008. See note to Figure 21. The detrended supply and wage series are the residuals from separate OLS regressions of the relative supply and relative wage measures on a constant and a linear time trend.
Figure 2
Actual versus Predicted College Wage Premium: 1915 to 2005

Sources and Notes: The actual values for the college wage premium are from the series used in the regressions in Table 2 and documented in the notes to Table 2. The two series for the predicted college wage premium are the values of the college wage premium predicted from the regressions in col. (2) and col. (3) of Table 2, as noted in the figure.
### GROWTH OF WAGE BILL SHARES, 1980-2004 (TRADED)

#### A. Dependent variable: ΔCollege Wage Bill Share

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Country fixed effects (11)</th>
<th>Control for Δ(non-ICT capital/value added)</th>
<th>Control for Δln(value added)</th>
</tr>
</thead>
<tbody>
<tr>
<td>∆ ((ICT capital) / (Value Added))</td>
<td>163.94</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>(45.48)</td>
<td>128.71</td>
<td>41.59</td>
<td>83.94</td>
</tr>
<tr>
<td>Intercept</td>
<td>9.12</td>
<td>6.42</td>
<td>4.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.86)</td>
<td>(1.02)</td>
<td>(2.19)</td>
<td></td>
</tr>
</tbody>
</table>

#### B. Dependent variable: ΔMedium-skilled Wage Bill Share

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Country fixed effects (11)</th>
<th>Control for Δ(non-ICT capital/value added)</th>
<th>Control for Δln(value added)</th>
</tr>
</thead>
<tbody>
<tr>
<td>∆ ((ICT capital) / (Value Added))</td>
<td>-163.98</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>(115.77)</td>
<td>288.01</td>
<td>83.94</td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>15.5</td>
<td>18.20</td>
<td>29.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.90)</td>
<td>(2.95)</td>
<td>(4.67)</td>
<td></td>
</tr>
</tbody>
</table>

#### C. Dependent variable: ΔLow-skilled Wage Bill Share

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Country fixed effects (11)</th>
<th>Control for Δ(non-ICT capital/value added)</th>
<th>Control for Δln(value added)</th>
</tr>
</thead>
<tbody>
<tr>
<td>∆ ((ICT capital) / (Value Added))</td>
<td>0.50</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>(113.51)</td>
<td>159.65</td>
<td>79.30</td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-18.74</td>
<td>-19.26</td>
<td>-33.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.12)</td>
<td>(1.31)</td>
<td>(3.95)</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Estimated by OLS in long differences (robust standard errors) 84 observations
EXAMPLES OF “AMAZING” THINGS ROBOTS CAN DO

• [http://www.youtube.com/watch?v=CsS1jnlxf4s&feature=related](http://www.youtube.com/watch?v=CsS1jnlxf4s&feature=related)
  Playing football. Badly
• [http://www.youtube.com/watch?v=UQjtEMokT_Q&feature=player_embedded](http://www.youtube.com/watch?v=UQjtEMokT_Q&feature=player_embedded). Crawling
• [http://fliiby.com/file/312678/iue10e1swz.html](http://fliiby.com/file/312678/iue10e1swz.html)
• [http://www.youtube.com/watch?v=w0MffPksN4M&feature=channel](http://www.youtube.com/watch?v=w0MffPksN4M&feature=channel). Unfair fights
• [http://www.youtube.com/watch?v=gQpqiMyFXXE&NR=1](http://www.youtube.com/watch?v=gQpqiMyFXXE&NR=1)