# Lecture 9: Labour economics

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**Literature:** Chapter 10 Cahuc-Carcillo-Zylberberg: 633-638
Bennmarker-Calmfors-Seim
Foged and Peri

## Topics

- **Technological progress and unemployment**
- **Skill-biased technological progress and wage inequality**
- **Skill-biased technological progress and wage rigidity**
- **US versus Europe**
- **Low-skilled wages and immigration**
- **Wages, working time and the Earned Income Tax Credit in Sweden**

## Technological progress

- **Labour productivity growth**
- **Capitalisation effect increases the profit due to job creation.**
- **The individual's productivity *y* grows at the rate *g*.**
- **Assume a balanced growth path where productivity, the real wage and profits all increase at the rate of *g*.**

$\pi_e$ = **profit from a filled vacancy (discounted value)**

$\pi_V$ = **profit from an unfilled vacancy (discounted value)**

$$\pi_e = \frac{1}{1 + rdt}\left[(y - w)dt + qdt(1 + gdt)\pi_V + (1 - qdt)(1 + gdt)\pi_e\right] \quad (3)$$

***q*** **= rate of job destruction**

**Equation (3) can be rewritten:**

$$(r - g)\pi_e = (y - w) + q(1 + gdt)(\pi_V - \pi_e)$$

$$dt \to 0 \Rightarrow$$

$$(r - g)\pi_e = (y - w) + q(\pi_V - \pi_e) \quad (4)$$

$$r\pi_e = (y - w) + q(\pi_V - \pi_e) + g\pi_e$$

- **If $\pi_e$ is "invested" in the labour market it earns a return made up of the instantaneous profit $(y - w)$ and an expected "capital gain" $q(\pi_V - \pi_e)$.**
- **In addition the value of the asset has risen by $g\pi_e$.**
- **A financial investment yields $r\pi_e$.**
- **$(r - g)\pi_e$ is the return from a financial investment less the "opportunity cost" $g\pi_e$ in an environment characterized by growth $g$.**
- **$(r - g)\pi_e$ is the <u>effective</u> rate of return on an investment.**
- **Growth is accompanied by a capitalisation effect equivalent to a reduction in the interest rate.**
- **The cost of a vacancy is assumed to be indexed to productivity, i.e. it is *hy*.**

**<u>The return from an unfilled vacancy</u>**

$$(r - g)\pi_V = -hy + m(\theta)(\pi_e - \pi_V) \qquad (4a)$$

**The free-entry condition $\pi_V$ = 0 together with (4) and (4a) give:**

$$\frac{y - w}{r - g + q} = \frac{hy}{m(\theta)} \qquad (5)$$

**The expected present value from a filled job, $\pi_e$, is equal to the average cost of a vacancy, $hy / m(\theta)$.**

- **(5) represents labour demand.**
- $g \uparrow \Rightarrow LHS \uparrow \Rightarrow \pi_e \uparrow$
- **Hence, the *RHS*, the cost of an unfilled vacancy, must also go up. This occurs if the average duration of a vacancy** $1/m(\theta)$ **increases, which happens when labour market tightness increases.**
- **Hence,** $g \uparrow \Rightarrow \theta \uparrow$**, i.e. an upward shift of the labour demand schedule.**

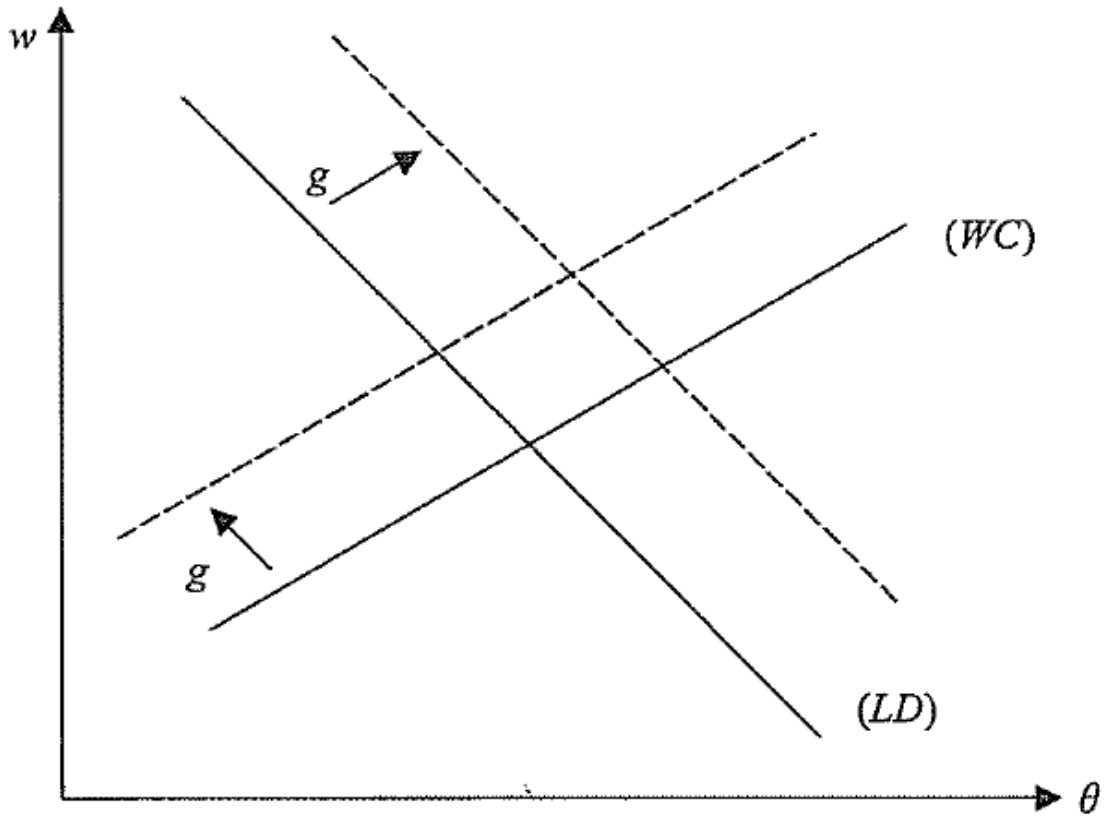


**FIGURE 10.1**
The effect of an increase in productivity.

**Wage setting**

$V_e$ **= the present value of an employed worker**

$V_u$ **= the present value of an unemployed worker**

$$(r-g)V_e = w + q(V_u - V_e) \qquad (6)$$

**We assume that the income of an unemployed worker is indexed to productivity, such that it is *zy*.**

**Then:**

$$(r-g)V_u = zy + \theta m(\theta)(V_e - V_u) \qquad (7)$$

**Apply the same wage bargaining model as in chapter 9, but change *z* to *zy* and *r* to (*r*-*g*).**

**Equation (20) in chapter 9 can then be rewritten:**

$$w = y\left[z + (1-z)\Gamma(\theta)\right]$$

$$\Gamma(\theta) = \frac{\gamma\left[r-g+q+\theta m(\theta)\right]}{r-g+q+\gamma\theta m(\theta)} \qquad (8)$$

- **The "strength of the employee in bargaining", $\Gamma(\theta)$, increases with $g$.**
- **$g \uparrow$ reduces the effective interest rate.**
- **The "capital loss" from job destruction is increased.**
- **Hence, relatively better to be unemployed.**
- **WC curve is shifted upwards.**

**<u>From Figure 10.1</u>**

**A rise in productivity growth:**

**(i) raises the wage**

**(ii) has an ambiguous effect on $\theta$.**

**But (5) and (8) together give:**

$$\frac{(1-\gamma)(1-z)}{r-g\ +\ q\ +\ \gamma\theta m(\theta)} = \frac{h}{m(\theta)} \qquad (9)$$

**Differentiation of (9) shows that rise in *g* raises *θ*.**

$$\frac{d\theta}{dg} = \frac{h}{h\gamma\underbrace{\left[m(\theta)\ +\ \theta m'(\theta)\right]}_{(+)} - \underbrace{(1-\gamma)(1-z)m'(\theta)}_{(+)}} > 0$$

## The Anglo-Saxon vs the European model

- **Biased technological progress**
- **Two labour markets: skilled and unskilled labour**
- **Three goods**
  - **final good**
  - **two intermediate goods (one produced with skilled labour; one produced with unskilled labour)**
- **Each employee produces one intermediate good per unit of time.**

## Production of the final good

$F(A_h L_h,\ A_l L_l)$ **and** $A_h$ **and** $A_l$ **measure the levels of technical progress**

- **The market for the final good is perfectly competitive.**

$$\underset{L_h, L_l}{\text{Max}} \quad F(A_h L_h,\ A_l L_l) - p_h L_h - p_L L_L$$

$$p_i = A_i F_i(A_h L_h,\ A_l L_l) \qquad i = h,\ l$$

$$\frac{p_h}{p_l} = \frac{A_h F_h(A_h L_h, A_l L_l)}{A_l F_l(A_h L_h, A_l L_l)}$$

**Stationary state**

$$r\pi_i = p_i - w_i + q_i(\pi_{Vi} - \pi_i) \qquad (39)$$

$h_i$ **= cost of a vacancy**

$\theta_i = V_i / U_i =$ **labour market tightness**

$m(\theta_i) = M_i(V_i / U_i)/V_i =$ **the rate at which vacant jobs of type *i* are filled**

$$r\pi_{Vi} = -h_i + m_i(\theta_i)(\pi_i - \pi_{Vi}) \qquad (40)$$

**From free-entry condition** $\pi_{Vi}$ **= 0, (39) and (40) we have:**

$$\frac{h_i}{m(\theta_i)} = \frac{p_i - w_i}{r + q_i} \qquad (41)$$

**Wage negotiations**

$z_i$ **= income of an unemployed person**

$V_{ei}$ **= discounted utility of an employed *i* worker**

$V_{ui}$ **= discounted utility of an unemployed *i* worker**

$$rV_{ei} = w_i + q_i(V_{ui} - V_{ei})$$

$$rV_{ui} = z_i + \theta_i m(\theta_i)(V_{ei} - V_{ui})$$

**From eq. (20) in chapter 9**

$$w_i = z_i + (p_i - z_i)\Gamma_i(\theta_i) \qquad (42)$$

$$\Gamma_i(\theta_i) = \frac{\gamma_i\left[r + q_i + \theta_i m(\theta_i)\right]}{r + q_i + \gamma_i\theta_i m(\theta_i)} \qquad i = h,\ l$$

$$z_i = b_i w_i$$

$$h_i = hp_i$$

$$w_i = b_i w_i + (p_i - b_i w_i)\Gamma_i(\theta_i)$$

$$w_i = p_i\Phi(\theta_i) \qquad \Phi(\theta_i) = \frac{\Gamma_i(\theta_i)}{1 - b_i + b_i\Gamma_i(\theta_i)} \quad i = 1,\ 2 \qquad (42a)$$

**(41) and (42a) give:**

$$\frac{h}{m_i(\theta_i)} = \frac{1 - \Phi_i(\theta_i)}{r + q_i}$$

- **Labour market tightness is independent of the prices of the intermediate goods and thus of technological progress.**
- **Hence, unemployment from the Beveridge curve does not depend on technological progress (bias).**
- **But the relative wage $w_l / w_h$ does depend on technological bias (prices).**
- **This is an Anglo-Saxon labour market.**

## A European labour market

- **Unskilled workers are paid a minimum wage.**
- **Assumption: The minimum wage is indexed to the wage of skilled workers.**

$$w_l = \mu w_h = \mu p_h \Phi_h(\theta_h) \qquad 0 \leq \mu \leq 1$$

$$\frac{h_l}{m(\theta_l)} = \frac{p_l - w_l}{r + q_l} = \frac{p_l - \mu p_h \Phi_h(\theta_h)}{r + q_l}$$

$$\frac{hp_l}{m(\theta_l)} = \frac{p_l - \mu p_h \Phi_h(\theta_h)}{r + q_l}$$

$$\frac{h}{m(\theta_l)} = \frac{1 - \mu \frac{p_h}{p_l} \Phi_h(\theta_h)}{r + q_l}$$

- **Obviously $\theta_l$ is affected by a change in $p_h / p_l$ due to technological bias.**
- **$\theta_h$ is determined as in the Anglo-Saxon model and is not affected by technological bias.**
- **It follows that relative unemployment is affected by technological bias.**

**CES production function**

$$F(A_h L_h,\ A_l F_l) \ = \ \left[(A_h L_h)^{(\sigma-1)/\sigma} \ + \ (A_l L_l)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}$$

$$\frac{p_h}{p_l} \ = \ \left(\frac{A_h}{A_l}\right)^{(\sigma-1)/\sigma} \left(\frac{L_h}{L}\right)^{-1/\sigma} \qquad (46)$$

**Anglo-Saxon model**

$$\frac{w_h}{w_l} \ = \ \left(\frac{A_h}{A_l}\right)^{(\sigma-1)/\sigma} \left[\frac{N_h(1-u_h)}{N_l(1-u_l)}\right]^{-1/\sigma} \qquad \frac{\Phi_h(\theta_h)}{\Phi_l(\theta_l)}$$

**European labour market**

**(46) together with** $L_i \ = \ N_i(1-u_i)$ **and**

$$\frac{h_l}{m_l(\theta_l)} \ = \ \frac{p_l - w_l}{r \ + \ q_l}$$

**gives:**

$$\frac{h(r \ + \ q_l)}{m_l(\theta_l)} \ = \ 1 - \mu\left(\frac{A_h}{A_l}\right)^{(\sigma-1)/\sigma} \left[\frac{N_h(1-u_h)}{N_l(1-u_l)}\right]^{-1/\sigma} \Phi_h(\theta_h)$$

- $\theta_h$ **and** $u_h$ **are independent of technological bias.**
- **It can be derived that** $\nu_l = \nu_l(u_l)$
- **Rise of** $x = A_h / A_l$ **with** $\sigma > 1$ **shifts *LD* curve downwards in Figure 10.11.**
- $u_l \uparrow$ **and** $\frac{u_l}{u_h} \uparrow$**.**

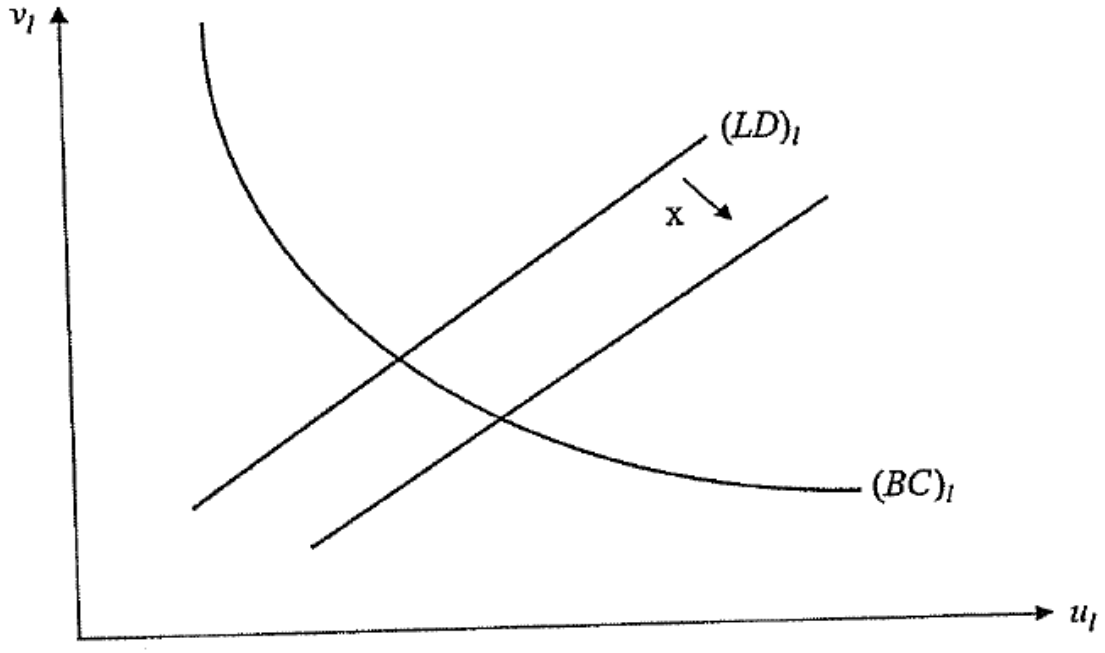


**FIGURE 10.11**
The unskilled labor market equilibrium.

# Wage effects of immigration

- Current Swedish debate on lower minimum wages to help labour market integration of low-skilled immigrants
- Fear that this will cause lower wages for low-skilled natives as well
- No available research on this issue
- But research in other countries on the effects of low-skilled immigration on wages of low-skilled natives
- Some studies have found **positive** or **no** effects
- Methodological problems with these studies
  - causality: immigration can be driven by demand (not supply)
  - not panel data on individuals: instead cross-sectional data on regions (encompassing both incumbents and those who move in but not those who move out)

# Foged-Peri study of Denmark

- Supply-driven allocation of refugee immigrants to Denmark 1986-1998
  - allocation according to housing situation (not labour-demand situation)
  - natural experiment (quasi-experiment)
- Results
  - Less educated native workers are pushed to change occupation (moves to non-manual occupations especially when changes of establishment)
  - Positive or null wage and employment effects on native workers
  - Cohort-based and area-based analyses give similar results

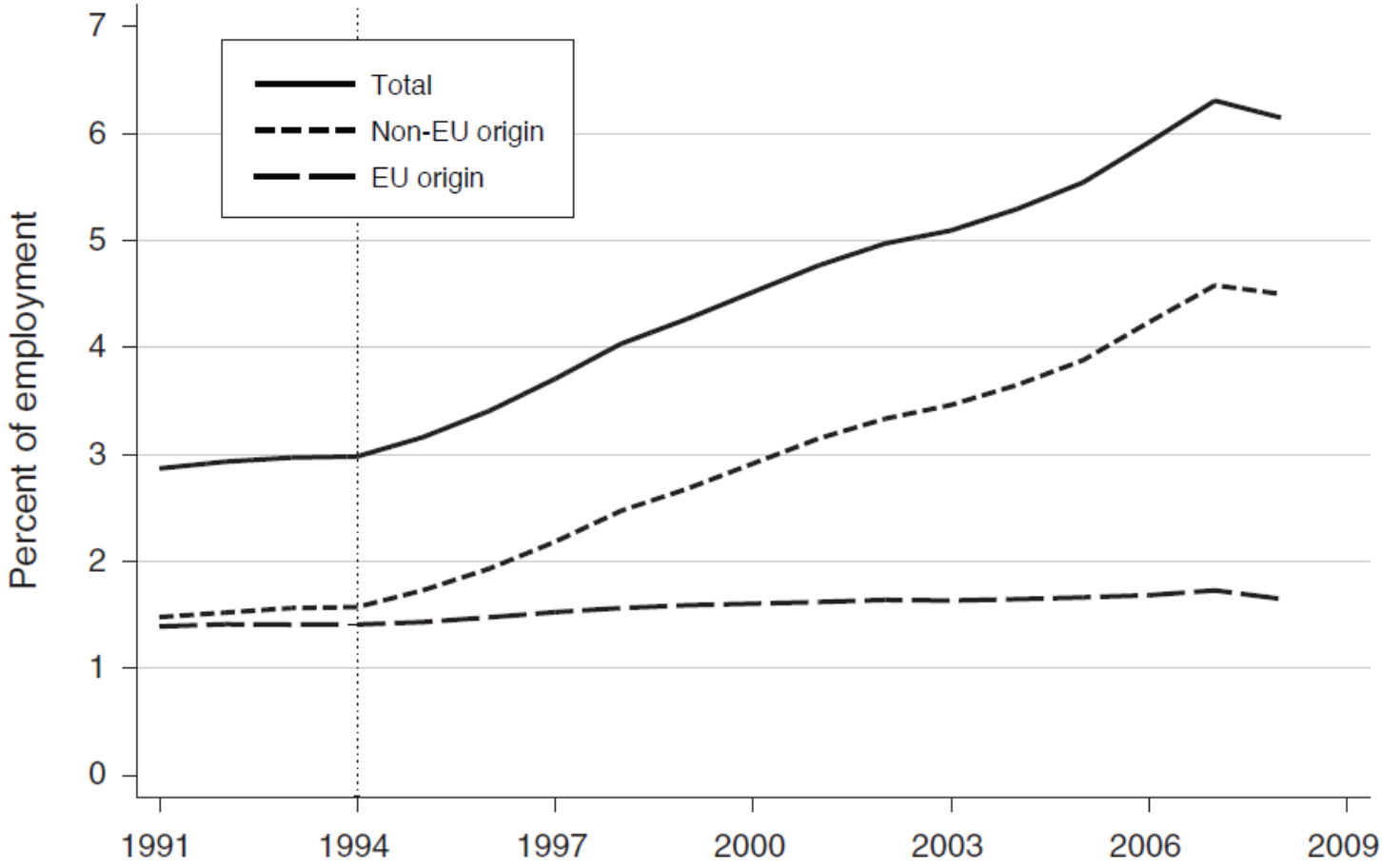


FIGURE 1. FOREIGN BORN SHARE IN DENMARK, 1991–2008

TABLE 2—SKILL LEVELS

| | Refugee | Natives |
|---|---|---|
| *Panel A. Education* | | |
| Primary | 0.292 | 0.265 |
| Secondary | 0.104 | 0.059 |
| Vocational | 0.293 | 0.403 |
| Higher | 0.214 | 0.265 |
| Unknown | 0.097 | 0.008 |
| *Panel B. Occupation* | | |
| Most complex | 0.000 | 0.002 |
| Least complex | 0.134 | 0.041 |
| Best paid | 0.003 | 0.030 |
| Least paid | 0.026 | 0.030 |

*Notes:* Observations with unknown education in the register likely have foreign education. Occupation groups are the 2-digit ISCO classifications.

TABLE 3—SKILL CONTENT OF OCCUPATIONS AND CHANGE IN REFUGEE IMMIGRANTS SHARE, 1994–2008

| | Difference in refugee share | Skill content of occupation | | | |
|---|---|---|---|---|---|
| | | Cognitive | Communication | Manual | Complexity |
| *Panel A. Lowest inflow* | | | | | |
| Managers of small enterprises | −0.003 | 0.666 | 0.677 | 0.432 | 1.136 |
| Legislators and senior officials | 0.001 | 0.897 | 0.989 | 0.303 | 1.828 |
| Skilled agricultural and fishery workers | 0.001 | 0.362 | 0.248 | 0.736 | −0.328 |
| Corporate managers | 0.002 | 0.796 | 0.796 | 0.367 | 1.488 |
| Armed forces | 0.002 | 0.441 | 0.390 | 0.633 | 0.225 |
| *Panel B. Highest inflow* | | | | | |
| Laborers in mining, construction, manufacturing, and transport | 0.022 | 0.215 | 0.156 | 0.769 | −0.783 |
| Drivers and mobile plant operators | 0.023 | 0.352 | 0.265 | 0.810 | −0.322 |
| Other elementary occupations | 0.027 | 0.260 | 0.205 | 0.742 | −0.633 |
| Machine operators and assemblers | 0.036 | 0.276 | 0.146 | 0.790 | −0.655 |
| Sales and services elementary occupations | 0.051 | 0.126 | 0.103 | 0.695 | −1.234 |

*Notes:* Complexity index = ln((Communication + Cognitive)/Manual). The skill content of each occupational grouping (2-digit ISCO) is the population weighted average of the underlying occupations (4-digit ISCO).

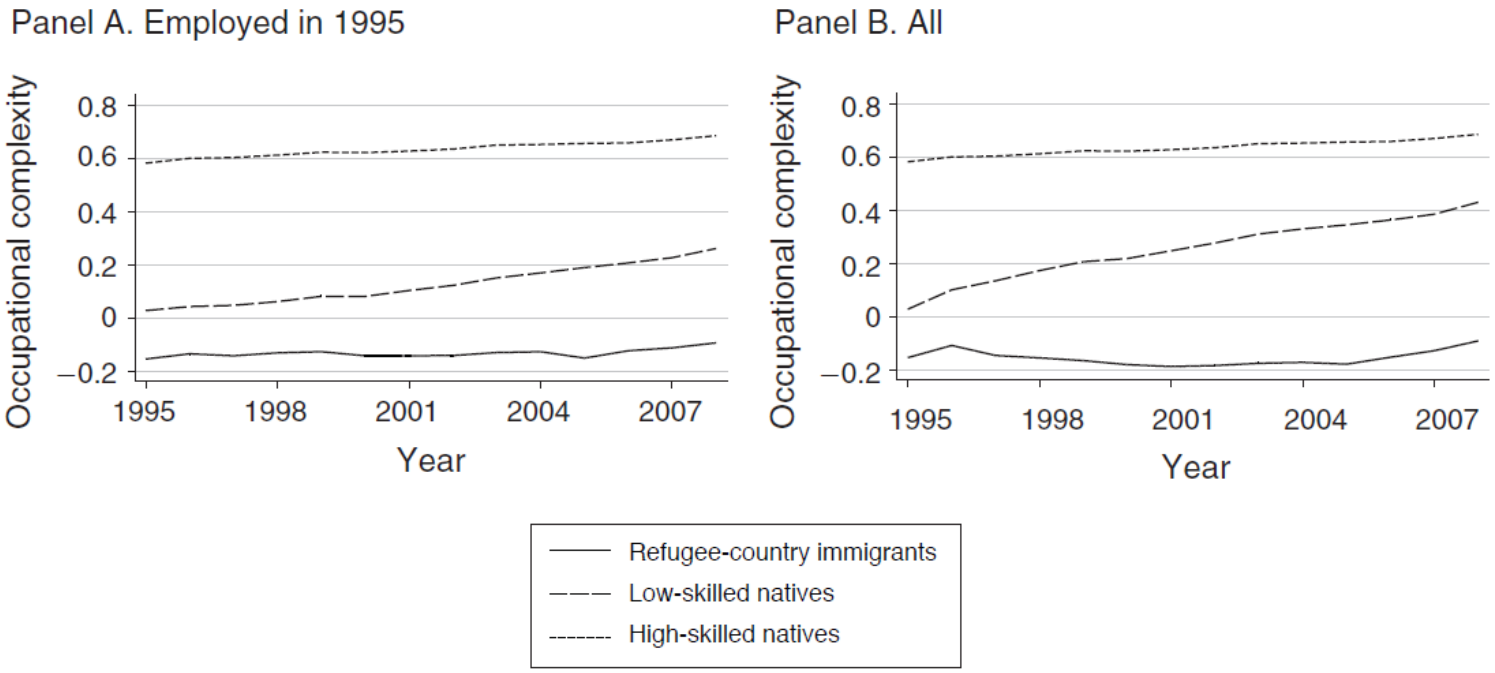


FIGURE 3. MEAN COMPLEXITY OF TASKS OVER TIME FOR GROUPS OF WORKERS

*Notes:* Each year the figure shows (for three groups) the mean complexity of tasks performed by either those employed in 1995 (panel A) or all, i.e., including new entrants to Danish employment (panel B).

$$y_{ijmt}^{NAT} = x_{it}'\alpha + \beta S_{mt} + \phi_{t,IND} + \phi_{t,REG} + \gamma_{i,u} + \varepsilon_{ijmt},$$

where

$y_{ijmt}^{NAT}$ = complexity, wages or employment

$x_{it}$ = vector of time-varying individual characteristics

$S_{mt}$ = refugee immigrant share of employment

$\phi_{t,IND}$ = industry-by-year effects

$\phi_{t,REG}$ = region-by-year effects

$\gamma_{i,u}$ = various fixed effects

$\varepsilon_{ijmt}$ = error term

$$y_{imt}^{NAT} = x_{it}'\alpha + \sum_{s=-3}^{-1} \gamma_S M_m D(year = s) + \sum_{s=1}^{14} \gamma_S M_m D(year = s) + \phi_{t,IND} + \phi_{t,REG} + \phi_{t,EDUC} + \phi_{t,OCC} + \phi_m + \varepsilon_{it},$$

where

$y_{imt}^{NAT}$ = complexity, wages or employment

$x_{it}$ = vector of time-varying individual characteristics

$M_m$ = treatment dummy (upper or lower quartile of refugee inflows)

$\phi_{t,IND}$ = industry-by-year effects

$\phi_{t,REG}$ = region-by-year effects

$\phi_{t,EDUC}$ = education-by-year effects

$\phi_{t,OCC}$ = occupation-by-year effects

$\phi_m$ = fixed municipality effects

# Instrumentation of Refugee Immigration

$F_{ct}$ = total refugee immigration from country $c$ in year $t$

$S_{cm}$ = share of immigrants from country $c$ who settled in municipality $m$ 1986-1998

$\hat{F}_{cmt}$ for $t > 1994 = S_{cm}$ x $F_{ct}$ = imputed working-age population from refugee-sending country $c$ in year $t$

$\hat{S}_{mt} = \frac{\sum_c \hat{F}_{cmt}}{P_{m1998}}$

$P_{m1998}$ = total working-age population in municipality $m$ in 1998

TABLE 6—FIXED EFFECT REGRESSIONS, LOW SKILLED

| | Worker-establishment | | Worker-municipality | | Worker | |
|---|---|---|---|---|---|---|
| | FE (1) | FE-IV (2) | FE (3) | FE-IV (4) | FE (5) | FE-IV (6) |
| Occupational complexity | 0.255 | 0.259 | 1.310* | 3.170* | 0.602* | 1.340** |
| | (0.326) | (0.580) | (0.612) | (1.534) | (0.275) | (0.478) |
| Manual intensity | −0.122 | −0.289 | −0.717** | −1.947** | −0.388** | −0.851*** |
| | (0.143) | (0.337) | (0.224) | (0.680) | (0.131) | (0.230) |
| Communication intensity | −0.144 | −0.514 | 0.200 | 0.559 | 0.156 | 0.668* |
| | (0.315) | (0.526) | (0.512) | (1.001) | (0.210) | (0.333) |
| Cognitive intensity | 0.327 | 0.144 | 0.821* | 1.417 | 0.213 | 0.238 |
| | (0.198) | (0.488) | (0.407) | (0.855) | (0.148) | (0.233) |
| Occupational mobility | 0.320 | 1.004 | 0.502 | 1.933* | 0.931*** | 1.781*** |
| | (0.295) | (0.785) | (0.412) | (0.983) | (0.214) | (0.457) |
| Hourly wage | 0.620* | 1.601** | 0.169 | 0.983 | 0.787** | 1.802** |
| | (0.265) | (0.507) | (0.351) | (0.601) | (0.300) | (0.642) |
| Fraction of year worked | 0.151 | 0.554* | 0.259* | 0.794** | 0.408*** | 0.735*** |
| | (0.129) | (0.262) | (0.106) | (0.287) | (0.066) | (0.101) |
| Observations | 1,564,737 | 1,564,737 | 1,816,727 | 1,816,727 | 1,864,027 | 1,864,027 |
| First-stage $F$-statistic | | 53.53 | | 58.01 | | 468.87 |
| First-stage coefficient | | 0.551*** | | 0.603*** | | 0.476*** |
| | | (0.075) | | (0.079) | | (0.022) |

TABLE 7—FIXED EFFECT REGRESSIONS, HIGH SKILLED

| | Worker-establishment | | Worker-municipality | | Worker | |
|---|---|---|---|---|---|---|
| | FE (1) | FE-IV (2) | FE (3) | FE-IV (4) | FE (5) | FE-IV (6) |
| Occupational complexity | −0.038 | 0.245 | 0.406 | 1.149** | 0.288* | 0.477* |
| | (0.256) | (0.457) | (0.256) | (0.410) | (0.139) | (0.220) |
| Manual intensity | −0.132 | −0.448 | −0.308* | −0.777** | −0.237*** | −0.387*** |
| | (0.112) | (0.243) | (0.120) | (0.246) | (0.070) | (0.096) |
| Communication intensity | −0.346 | −0.239 | 0.005 | 0.484 | 0.050 | 0.218 |
| | (0.224) | (0.361) | (0.246) | (0.352) | (0.122) | (0.176) |
| Cognitive intensity | −0.084 | −0.447 | 0.101 | −0.009 | 0.021 | −0.096 |
| | (0.184) | (0.522) | (0.199) | (0.396) | (0.111) | (0.197) |
| Occupational mobility | 0.106 | 1.301* | 0.395 | 1.944*** | 0.209 | 0.378 |
| | (0.235) | (0.546) | (0.272) | (0.569) | (0.160) | (0.260) |
| Hourly wage | 0.512*** | 2.068*** | 0.522* | 2.316*** | −0.301 | −0.034 |
| | (0.148) | (0.452) | (0.203) | (0.584) | (0.381) | (0.483) |
| Fraction of year worked | −0.083 | 0.178 | −0.048 | 0.120 | 0.096* | 0.223*** |
| | (0.080) | (0.176) | (0.073) | (0.166) | (0.040) | (0.060) |
| Observations | 2,860,183 | 2,860,183 | 3,125,934 | 3,125,934 | 3,160,757 | 3,160,757 |
| First-stage *F*-statistic | | 63.28 | | 68.02 | | 294.85 |
| First-stage coefficient | | 0.563*** | | 0.607*** | | 0.495*** |
| | | (0.071) | | (0.074) | | (0.029) |

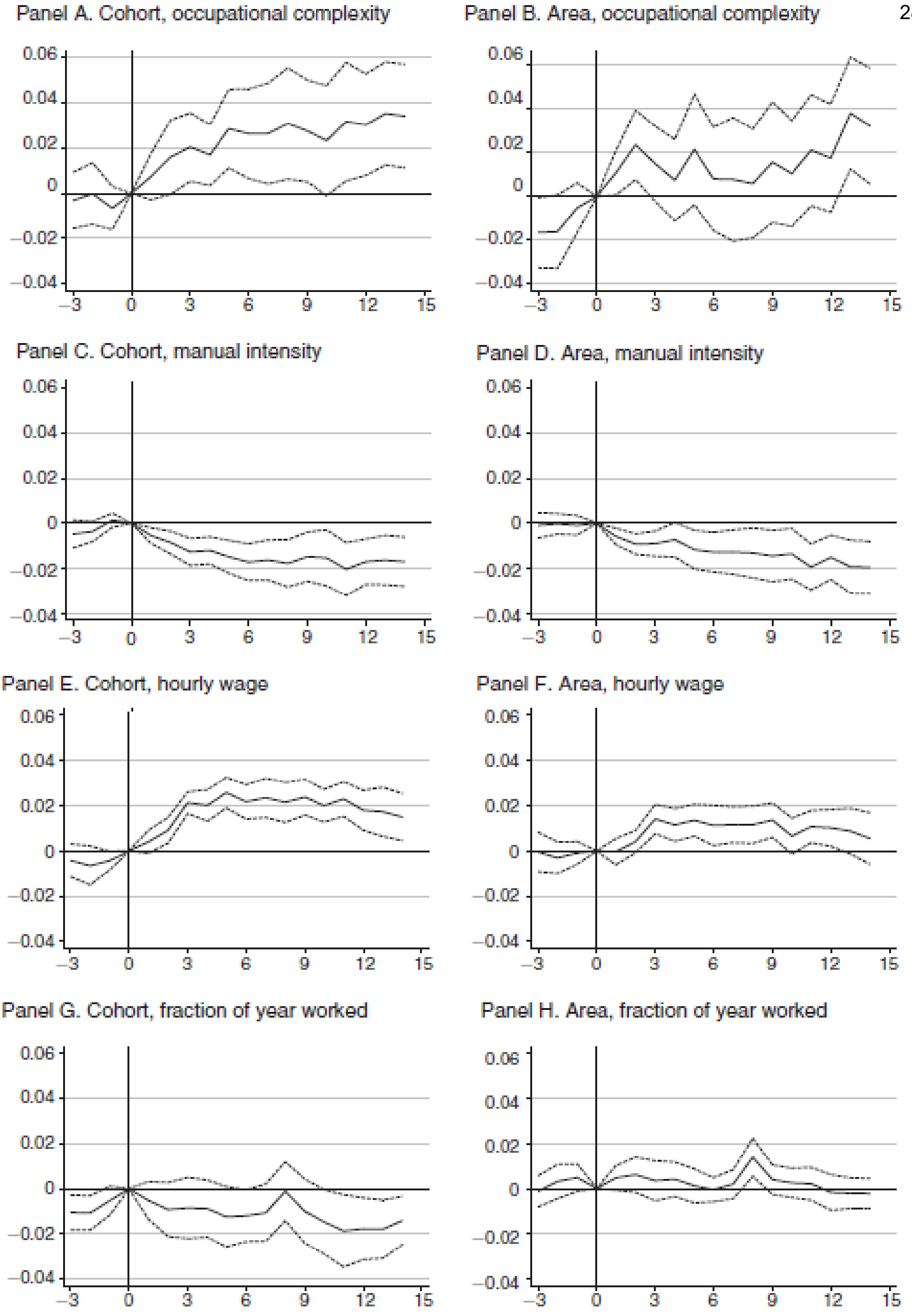


FIGURE 4. TREATMENT-CONTROL DIFFERENCES IN OUTCOMES, LOW SKILLED

# Benmarker-Calmfors-Seim model



$$rV_E^i = \omega_E^i + q\left(V_U - V_E^i\right) \quad (1)$$

$$rV_U = b + s(\theta)(V_E - V_U), \quad (2)$$

$s'(\theta) > 0.$

$$\omega_E^i = w^i - T_E\left(w^i\right)$$

$$r\Pi_E^i = y - \omega_F^i + q\left(\Pi_V^i - \Pi_E^i\right) \quad (3)$$

$$r\Pi_V^i = -h + m(\theta)\left(\Pi_E^i - \Pi_V^i\right), \quad (4)$$

$m'(\theta) < 0$

$$\omega_F^i = (1+\tau)w^i$$

$$\max_{lnw^i} \Lambda = \lambda ln\left(V_E^i - V_U\right) + (1-\lambda) ln\left(\Pi_E^i - \Pi_V^i\right)$$

where (1) implies

$$V_E^i - V_U = \frac{\omega_E^i - rV_U}{r+q}. \quad (5)$$

Since free entry of firms ensures that $\Pi_V^i = 0$, (3) gives:

$$\Pi_E^i - \Pi_V^i = \frac{y - \omega_F^i}{r + q}. \qquad (6)$$

Taking account of (5) and (6) and solving the optimization problem gives the first-order condition:

$$\frac{\partial ln\Lambda}{\partial lnw^i} = \lambda \frac{\mu^i \omega_E^i}{(\omega_E^i - rV_U)} - (1 - \lambda)\frac{\omega_F^i}{y - \omega_F^i} = 0, \qquad (7)$$

Coefficient av residual income progression:

$$\mu^i \equiv \frac{\partial ln\omega_E^i}{\partial lnw^i} = \frac{1 - T_E'(w^i)}{1 - T_E/w^i},$$

Using (1) and (2) to solve for $rV_U$ we obtain:

$$rV_U = \left[\frac{r + q}{r + q + s(\theta)}\right] b + \left[\frac{s(\theta)}{r + q + s(\theta)}\right] \omega_E$$

$$\lambda \frac{\mu^i}{(1 - \left(\frac{r + q}{r + q + s(\theta)}\right)\rho^i - \left(\frac{s(\theta)}{r + q + s(\theta)}\right)\omega_E/\omega_E^i)} = (1 - \lambda)\frac{\omega_F^i}{y - \omega_F^i}, \qquad (8)$$

where $\rho^i = b/\omega_E^i$ is the after-tax replacement rate of individual $i$.

Because $\omega_E^i = w^i - T_E(w^i), \omega_E = w - T_E(w)$ and $\omega_F^i = (1+\tau)w^i$, the condition (8) implicitly defines a real wage equation for an individual worker:

$$w^i = w^i(\rho^i, \mu^i, \tau, \theta, y, w; r, q, \lambda). \tag{9}$$

Differentiating (8), we find that:

$$\frac{\partial w^i}{\partial \rho^i} = \frac{(1-\lambda)(r+q)(w^i/\mu^i)}{\phi} > 0,$$

$$\frac{\partial w^i}{\partial \mu^i} = \frac{\lambda(r+q+s(\theta))(y/\omega_F^i - 1)(w^i/\mu^i)}{\phi} > 0,$$

$$\frac{\partial w^i}{\partial \tau} = -\frac{\lambda(r+q+s(\theta))(y/(1+\tau)^2)}{\phi} < 0,$$

$$\frac{\partial w^i}{\partial \theta} = \frac{(\omega_E/\omega_E^i - \rho^i)(1-\lambda)s'(\theta)(r+q)/(r+q+s(\theta))(w^i/\mu^i)}{\phi} \lesseqgtr 0,$$

$$\frac{\partial w^i}{\partial y} = \frac{\lambda(r+q+s(\theta))/(1+\tau)}{\phi} > 0,$$

$$\frac{\partial w^i}{\partial w} = \frac{(1-\lambda)s(\theta)(1-T_E'(w))(\mu w^i \omega_E/\mu^i w \omega_E^i)}{\phi} > 0,$$

where

$$\phi = (1-\lambda)s(\theta)(\omega_E/\omega_E^i) + \lambda(r+q+s(\theta))(y/\omega_F^i) > 0.$$

## Symmetric equilibrium

Imposing $w^i = w$ on (9) enables us to solve

$$w = \frac{1}{(1+\tau)} \frac{\lambda\mu(r+q+s(\theta))y}{[(1-\lambda)(1-\rho)(r+q)+\lambda\mu(r+q+s(\theta))]}. \quad (10)$$

Equation (10) now defines an aggregate equilibrium before-tax real wage

$$w = w(\rho, \mu, \tau, \theta, y; r, q, \lambda). \quad (11)$$

## Benchmark regression equation

$$\Delta lnw_{it} = \beta_0 + \beta_1 \Delta lnp_t + \beta_2 \Delta\rho_{it} + \beta_3 \Delta\mu_{it} + \beta_4 \Delta\tau_{it} + \beta_5 \Delta\theta_{it} + \sum_j \beta_{5+j} x_{ijt} + \epsilon_{it},$$

Table 1. Descriptive statistics, 2005-2009

| | Year | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|
| Monthly wage | Mean | 24 205 | 25 115 | 25 795 | 27 115 | 27 991 |
| | St Dev | 11 591 | 12 171 | 12 229 | 12 527 | 12 590 |
| | Min | 10 000 | 12 000 | 12 000 | 12 000 | 12 000 |
| | Max | 1 043 707 | 1 232 252 | 960 882 | 736 626 | 668 145 |
| Wage growth | Mean | .037 | .044 | .041 | .058 | .037 |
| | St Dev | .117 | .120 | .125 | .124 | .119 |
| | Min | -2.141 | -2.086 | -1.940 | -2.004 | -2.196 |
| | Max | 2.340 | 2.477 | 1.754 | 2.014 | 2.310 |
| Net replacement rate | Mean | .710 | .697 | .630 | .603 | .582 |
| | St Dev | .129 | .133 | .131 | .132 | .133 |
| | Min | .032 | .023 | .019 | .024 | .031 |
| | Max | .860 | .859 | .795 | .795 | .795 |
| Net replacement rate growth | Mean | | -.016 | -.072 | -.032 | -.023 |
| | St Dev | | .051 | .056 | .056 | .056 |
| | Min | | -.571 | -.654 | -.567 | -.575 |
| | Max | | .614 | .434 | .505 | .579 |
| Progressivity variable | Mean | .871 | .868 | .858 | .851 | .864 |
| | St Dev | .090 | .088 | .097 | .100 | .092 |
| | Min | .672 | .666 | .647 | .641 | .637 |
| | Max | 1 | 1 | 1 | 1 | 1 |
| Change in progressivity variable | Mean | | -.004 | -.012 | -.009 | .012 |
| | St Dev | | .067 | .068 | .073 | .080 |
| | Min | | -.314 | -.338 | -.354 | -.350 |
| | Max | | .319 | .326 | .339 | .346 |
| Local unemployment | Mean | .059 | .053 | .039 | .037 | .059 |
| | St Dev | .016 | .015 | .012 | .012 | .018 |
| | Min | .023 | .021 | .013 | .009 | .018 |
| | Max | .141 | .115 | .089 | .094 | .138 |
| Hours worked | Mean | .896 | .898 | .898 | .897 | .897 |
| | St Dev | .215 | .215 | .214 | .217 | .216 |
| | Min | .010 | .006 | .010 | .004 | .010 |
| | Max | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Age | Mean | 42.073 | 42.000 | 41.926 | 41.936 | 42.211 |
| Male | Mean | .500 | .506 | .501 | .503 | .498 |
| Max observations | | 119 438 | 119 236 | 124 426 | 122 977 | 119 296 |

Note: The net replacement rate and the progressivity variable are based on wage predictions. Local unemployment is calculated as the unemployment-to-population ratio. Both openly unemployed and participants in labour market programmes are counted as unemployed.

Table 2. Estimated wage equations. Replacement rate and progressivity variable based on lagged wages. Dependent variable: first difference of log nominal wage. 2006-2009

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inflation | | | | .766*** | .725*** | .724*** | .726*** | .740*** | .647*** | | | .514*** |
| | | | | (.014) | (.018) | (.018) | (.018) | (.018) | (.020) | | | (.021) |
| Change in replacement rate | .343*** | | .332*** | .367*** | .369*** | .368*** | .369*** | .365*** | .490*** | .395*** | .395*** | .547*** |
| | (.006) | | (.006) | (.006) | (.006) | (.006) | (.006) | (.006) | (.008) | (.007) | (.007) | (.004) |
| Change in Progressivity variable | | .111*** | .028*** | .040*** | .040*** | .040*** | .040*** | .040*** | .039*** | .034*** | .034*** | .040*** |
| | | (.003) | (.003) | (.003) | (.003) | (.003) | (.003) | (.003) | (.003) | (.003) | (.003) | (.003) |
| Change in unemployment rate | | | | | -.057*** | -.058*** | -.054*** | -.036** | -.319*** | -.121*** | -.121*** | -.007 |
| | | | | | (.017) | (.017) | (.017) | (.017) | (.019) | (.033) | (.033) | (.000) |
| Dummy for earlier unemployment | | | | | -.001*** | -.001 | -.001 | -.001 | .006*** | -.001 | -.001 | .001 |
| | | | | | (.001) | (.001) | (.001) | (.001) | (.001) | (.001) | (.000) | (.001) |
| Male | | | | -.018 | -.020 | -.027 | -.027 | .009 | -.498*** | -.019 | -.019 | |
| | | | | (.045) | (.045) | (.045) | (.045) | (.045) | (.049) | (.045) | (.045) | |
| Age | | | | -.089*** | -.089*** | -.226*** | -.217*** | -.231*** | -.363*** | -.224*** | -.236*** | -.005*** |
| | | | | (.002) | (.002) | (.015) | (.016) | (.015) | (.017) | (.015) | (.016) | (.001) |
| Age squared | | | | | | .157*** | .148*** | .163*** | .282*** | .153*** | .165*** | .000*** |
| | | | | | | (.017) | (.018) | (.016) | (.018) | (.017) | (.018) | (.000) |
| Payroll dummy 2007 | | | | | | | .004 | | | | -.002 | |
| | | | | | | | (.003) | | | | (.002) | |
| Payroll dummy 2009 | | | | | | | .000 | | | | -.003 | |
| | | | | | | | (.002) | | | | (.002) | |
| Controls | | | | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Entrepreneurs excluded | | | | | | | | Yes | | | | |
| Full-time employed | | | | | | | | | Yes | | | |
| Year dummies | | | | | | | | | | Yes | Yes | |
| Individual fixed effects | | | | | | | | | | | | Yes |
| N | 382 548 | 382 548 | 382 548 | 382545 | 382 545 | 382 545 | 382 545 | 374 786 | 291 656 | 382 545 | 382 545 | 382 545 |
| R2 | .031 | .005 | .031 | .048 | .048 | .049 | .049 | .049 | .078 | .050 | .050 | .084 |

Notes: Where indicated, the controls comprise educational level and type, region of birth and civil status. The constant is not reported. Robust standard errors are reported within parenthesis. ***: significant at the 1 per cent level; **: significant at the 5 per cent level; *: significant at the 10 per cent level. The coefficients and standard errors for Male and Age have been multiplied by 100, and the coefficient and standard errors for Age squared by $100^2$.

Table 3. Estimated wage equations. Replacement rate and progressivity variable based on estimated Mincer wages. Dependent variable: first difference of log nominal wage. 2006-2009

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inflation | | | | .660*** | .688*** | .685*** | .687*** | .707*** | .595*** | | | |
| | | | | (.015) | (.019) | (.019) | (.019) | (.019) | (.021) | | | |
| Change in replacement rate | .083*** | | .086*** | .220*** | .210*** | .203*** | .203*** | .201*** | .161*** | .324*** | .328*** | .641*** |
| | (.008) | | (.008) | (.009) | (.010) | (.010) | (.010) | (.010) | (.011) | (.022) | (.022) | (.024) |
| Change in progressivity variable | | -.015*** | -.017*** | .010*** | .009*** | .008*** | .008*** | .008*** | .008*** | .004 | .004 | .006* |
| | | (.003) | (.003) | (.003) | (.003) | (.003) | (.003) | (.003) | (.003) | (.003) | (.003) | (.003) |
| Change in unemployment rate | | | | | .051*** | .055*** | .052*** | .077*** | -.076*** | -.124*** | -.124*** | -.040 |
| | | | | | (.018) | (.018) | (.018) | (.018) | (.020) | (.034) | (.034) | (.039) |
| Dummy for earlier unemployment | | | | | .004*** | .004*** | .004*** | .004*** | .008*** | .004*** | .004*** | .007*** |
| | | | | | (.001) | (.001) | (.001) | (.001) | (.001) | (.001) | (.001) | (.001) |
| Male | | | | -.054 | -.039 | -.045 | -.044 | -.014 | -.237*** | -.047 | -.047 | |
| | | | | (.046) | (.046) | (.046) | (.046) | (.046) | (.050) | (.046) | (.046) | |
| Age | | | | -.090*** | -.088*** | -.263*** | -.259*** | -.266*** | -.388*** | -.253*** | -.259*** | -.994*** |
| | | | | (.002) | (.002) | (.014) | (.016) | (.014) | (.017) | (.015) | (.016) | (.092) |
| Age squared | | | | | | .204*** | .199*** | .208*** | .325*** | .189*** | .195*** | .897*** |
| | | | | | | (.016) | (.017) | (.016) | (.018) | (.016) | (.017) | (.091) |
| Payroll dummy 2007 | | | | | | | -.000 | | | | -.003 | |
| | | | | | | | (.003) | | | | (.003) | |
| Payroll dummy 2009 | | | | | | | .002 | | | | .001 | |
| | | | | | | | (.002) | | | | (.002) | |
| Controls | | | | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Entrepreneurs excluded | | | | | | | | Yes | | | | |
| Full-time employed | | | | | | | | | Yes | | | |
| Year dummies | | | | | | | | | | Yes | Yes | |
| Individual fixed effects | | | | | | | | | | | | Yes |
| N | 427 959 | 427 959 | 427 959 | 427 956 | 427 956 | 427 956 | 427 956 | 418 773 | 320 026 | 427 956 | 427 956 | 427 956 |
| R2 | .000 | .000 | .000 | .014 | .014 | .014 | .014 | .015 | .020 | .015 | .015 | .010 |

Notes: Where indicated, the controls comprise educational level and type, region of birth and civil status. The constant is not reported. Robust standard errors are reported within parenthesis. ***: significant at the 1 per cent level; **: significant at the 5 per cent level; *: significant at the 10 per cent level. The coefficients and standard errors for Male and Age have been multiplied by 100, and the coefficient and standard errors for Age squared by $100^2$.

Table 4 Estimated wage equations. IV estimations (2SLS). Replacement rate and progressivity variable instrumented by reform variables based on estimated Mincer wages. Dependent variable: first difference of log nominal wage. 2006-2009

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| Inflation | | | | .843*** | .745*** | .736*** | .743*** | .761*** | .675*** |
| | | | | (.048) | (.031) | (.031) | (.032) | (.031) | (.042) |
| Change in replacement rate | .107*** | | .201*** | .215*** | .246*** | .241*** | .241*** | .239*** | .181*** |
| | (.010) | | (.020) | (.024) | (.019) | (.019) | (.019) | (.019) | (.019) |
| Change in progressivity variable | | -.330*** | -.401*** | .442*** | .540*** | .485*** | .504*** | .494*** | .429*** |
| | | (.064) | (.074) | (.126) | (.155) | (.155) | (.161) | (.160) | (.155) |
| Change in unemployment rate | | | | | -.214*** | -.189*** | -.204*** | -.165*** | -.301*** |
| | | | | | (.059) | (.059) | (.064) | (.060) | (.064) |
| Dummy for earlier unemployment | | | | | .003*** | .003*** | .003*** | .003*** | .007*** |
| | | | | | (.001) | (.001) | (.001) | (.001) | (.001) |
| Male | | | | .044 | .073 | .061 | .064 | .095* | -.160*** |
| | | | | (.051) | (.053) | (.052) | (.053) | (.052) | (.059) |
| Age | | | | -.096*** | -.096*** | -.247*** | -.235*** | -.249*** | -.385*** |
| | | | | (.002) | (.002) | (.015) | (.017) | (.015) | (.017) |
| Age squared | | | | | | .176*** | .164*** | .180*** | .311*** |
| | | | | | | (.018) | (.020) | (.018) | (.021) |
| Payroll dummy 2007 | | | | | | | -.001 | | |
| | | | | | | | (.002) | | |
| Payroll dummy 2009 | | | | | | | .004** | | |
| | | | | | | | (.002) | | |
| Controls | | | | Yes | Yes | Yes | Yes | Yes | Yes |
| Entrepreneurs excluded | | | | | | | | Yes | |
| Full-time employed | | | | | | | | | Yes |
| N | 426 819 | 426 819 | 426 819 | 426 816 | 426 816 | 426 816 | 426 816 | 417 633 | 319 510 |

Notes: Where indicated, the controls comprise educational level and type, region of birth and civil status. The constant is not reported. Robust standard errors are reported within parenthesis. ***: significant at the 1 per cent level; **: significant at the 5 per cent level; *: significant at the 10 per cent level. The coefficients and standard errors for Male and Age have been multiplied by 100, and the coefficient and standard errors for Age squared by $100^2$.

Table 5. Estimated wage equations. Percentile income group level. Dependent variable: first difference of log mean nominal wage. 2006-2009

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Change in mean replacement rate | .200*** | .200*** | .199*** | .199*** | -.086 | -.078 |
| | (.046) | (.046) | (.046) | (.046) | (.182) | (.182) |
| Change in mean of progressivity variable | | .001 | | .000 | | .019 |
| | | (.017) | | (.017) | | (.016) |
| Group fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Weights | | | Yes | Yes | Yes | Yes |
| Year dummies | | | | | Yes | Yes |
| N | 400 | 400 | 400 | 400 | 400 | 400 |
| R2 | .060 | .060 | .060 | .060 | .255 | .258 |

Notes: Mean wages and reform variables computed over percentile income intervals, based on the 2006 income distribution implied by predicted Mincer wages. The constant is not reported. Robust standard errors are reported within parenthesis. ***: significant at the 1 per cent level; **: significant at the 5 per cent level; *: significant at the 10 per cent level. Weights indicate average group size.

$$dlnw^i \,/\, d\rho^i = \beta_2 = [0.2\,,0.4]$$

$$\rho^i = b/\omega_E^i$$

$$\omega_E^i = w^i - T_E\left(w^i\right) = (1-t)w^i$$

$$dlnw^i/dlnb = \beta_2\,\rho^i/\,(1+\beta_2\,\rho^i)$$

$$dlnw^i \,/\, dln(1-t) = -\beta_2\,\rho^i/\,(1+\beta_2\,\rho^i)$$

$$dln\omega_E^i \,/\, dln(1-t) = 1-\left[\beta_2\,\rho^i/\,(1+\beta_2\,\rho^i)\right]$$

$$\rho^i = 0.65 \Rightarrow \beta_2\,\rho^i/\left(1+\beta_2\,\rho^i\right) = [0.12\,,0.21]$$