Wiener Institut für Internationale Wirtschaftsvergleiche

The Vienna Institute for International Economic Studies

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Annual research conference, DG ECFIN

The productivity challenge:
Jobs and incomes in the dawning era of intelligent robots

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The machines' race against demography

Sandra Leitner and Robert Stehrer
The Vienna Institute for International Economic Studies - wiiw
www.wiiw.ac.at

Motivation

- Discussion on employment impacts of ‚new technologies' (digitisation, industry 4.0, ...)
  - Expected strong negative implications on employment demand levels is disputed
  - Implications for future qualifications, tasks, etc. is generally expected, though difficult to predict
- Increase in use / accumulation of ICT capital and use of ‚machines and robots'
  - Impact on productivity seems to be lower than expected („One can see computers everywhere, but not in productivity statistics"; R. Solow, 1987)
- Emerging labour shortages in many countries due to demographic trends
  - Already strongly visible in EU CEECs
  - Similar trends are foreseen for many other European countries

Race between impact of digitisation and demographic trends

- Do demographic trends kick in faster (at least in some countries)?
  - Leading to phase of demography-driven slow growth (at more or less constant productivity growth rates)
- Need for (ICT and robots) capital accumulation and associated productivity increases to compensate for demographic decline
  - But, can digitisation-induced (labour) productivity growth compensate for decline in labour supply?
- Note that mostly working-age population declines, whereas overall population still grows or remains at least constant (‚ageing‘)
  - Slower GDP/capita growth

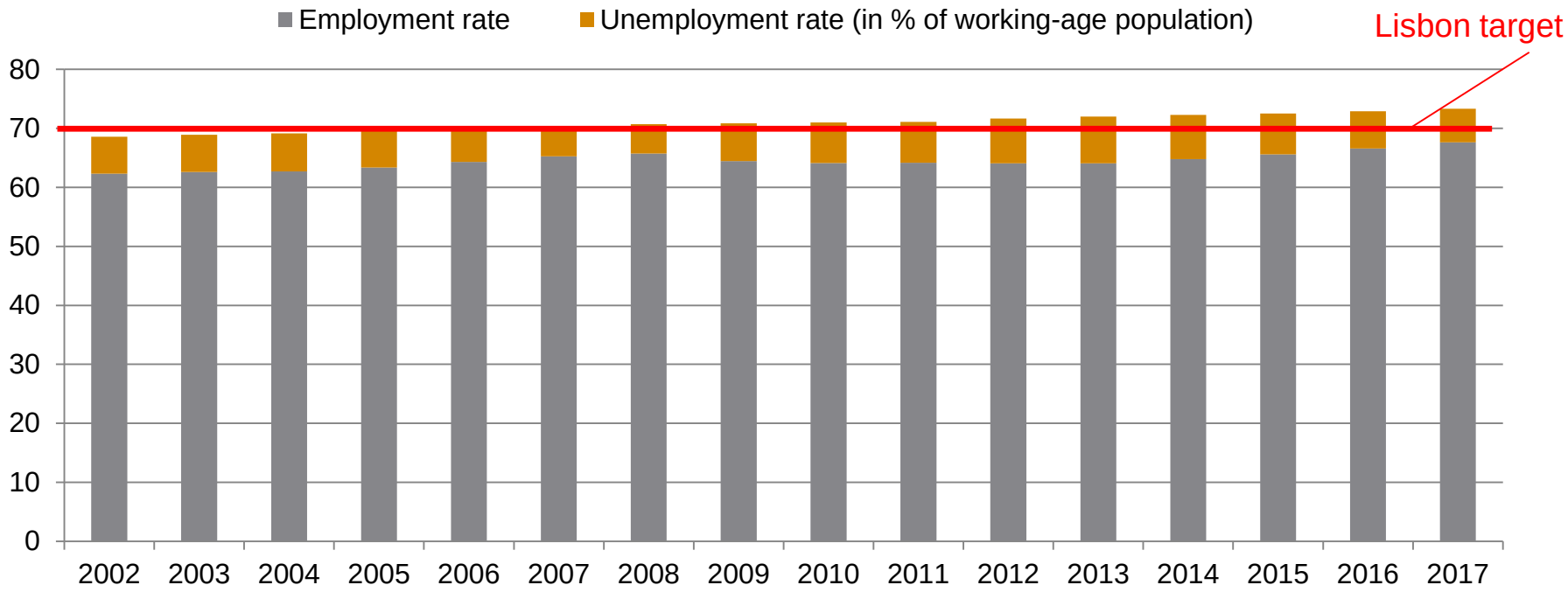
Content

- Selected stylized facts about labour demand and supply and demographic scenarios
- When does demography kick in? Results from a simple trend model
- Demographic aspects in standard growth theories
- The machines‘ race against demography
- Conclusions

Selected stylized trends

Labour supply and demand, EU-28

(expressed in % of working age population 15-64)

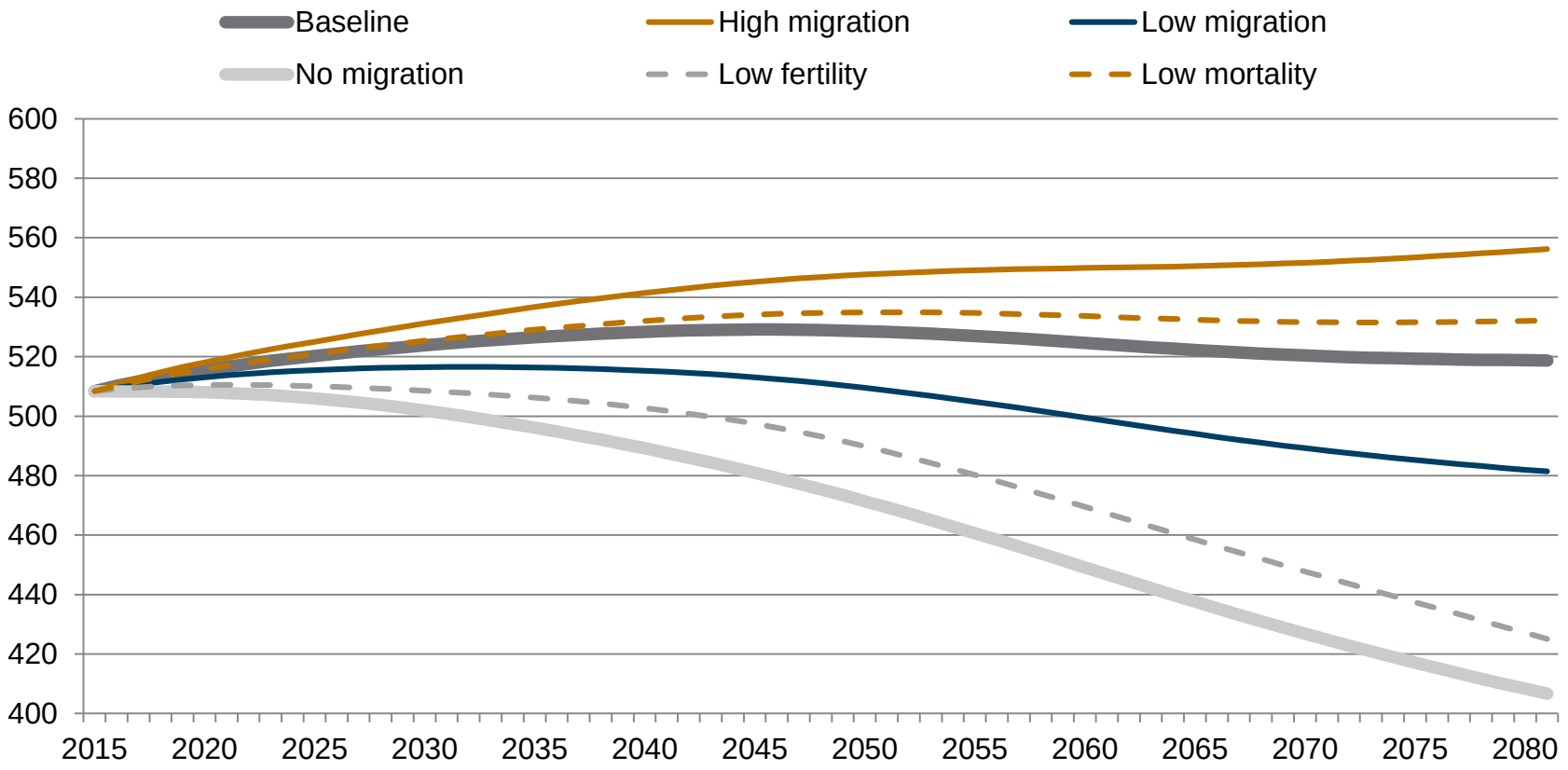


Note: Red line indicates Lisbon target (employment rate to be 70% of working age population)
Source: EU LFS data; own calculations

- Growth rate of working age population (15-64): 0.06%
- Growth rate of active population: 0.51%
- Growth rate of activity rate: 0.46%

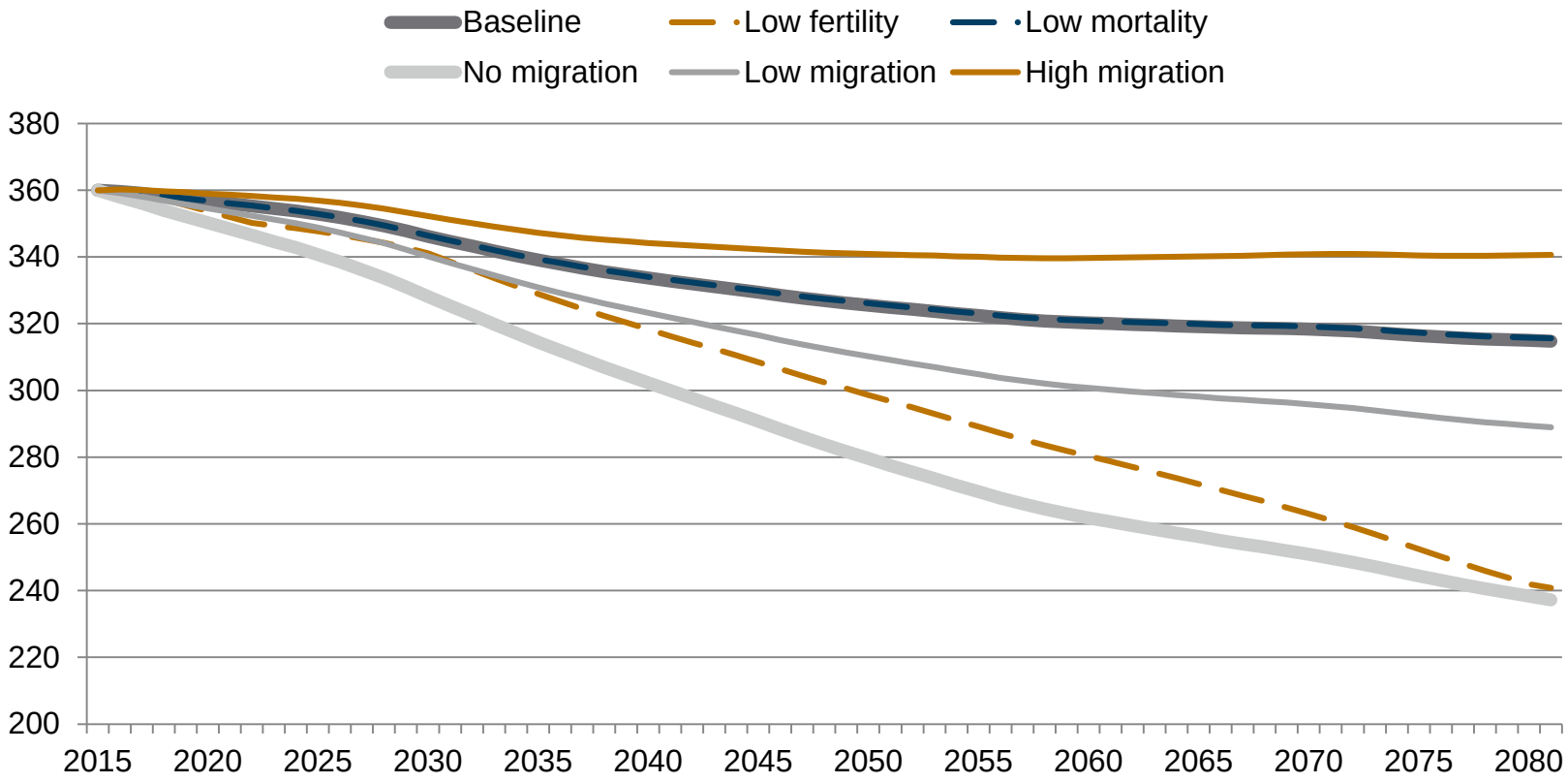
- Growth rate of employment: 0.61%

Population scenarios



Source: Eurostat; own calculations

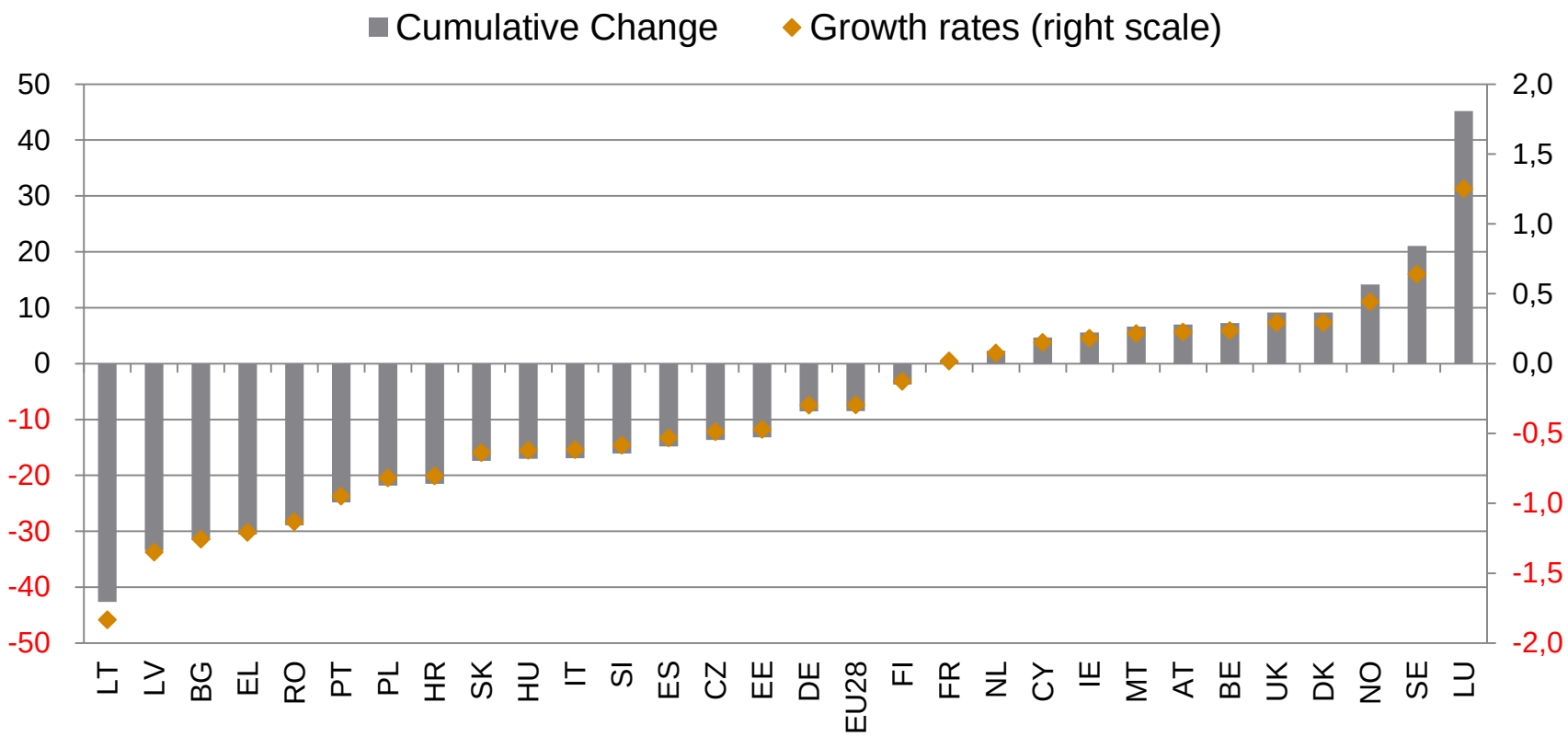
Scenarios for working age population



Note: The baseline and the low mortality scenario overlap
Source: Eurostat; own calculations

Scenarios for working age population

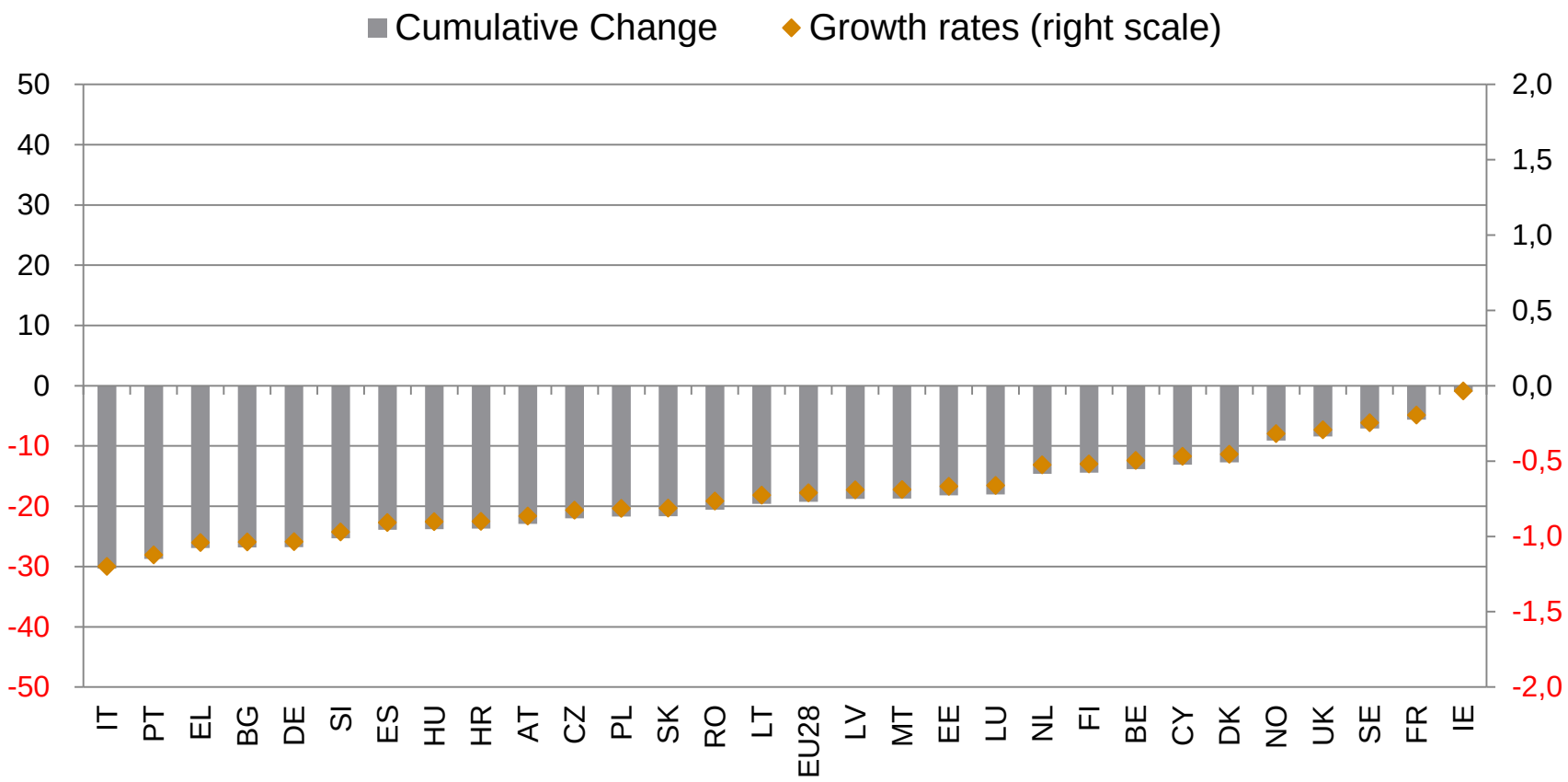
(15-64; baseline scenario; 2015-2045)



Source: Eurostat; own calculations

Scenarios for working age population

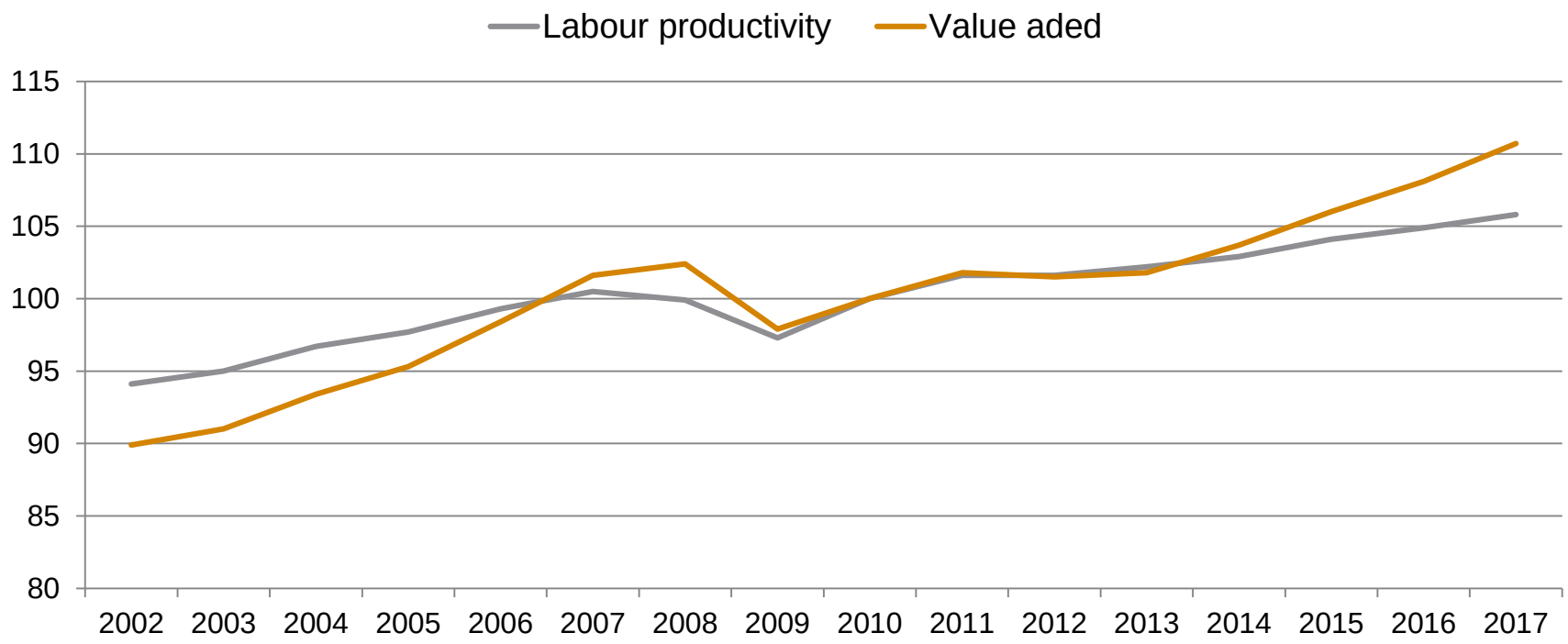
(15-64; no migration scenario; 2015-2045)



Source: Eurostat; own calculations

GDP and labour productivity

(GDP in real terms; labour productivity measured as GDP per person employed, 2010=100)

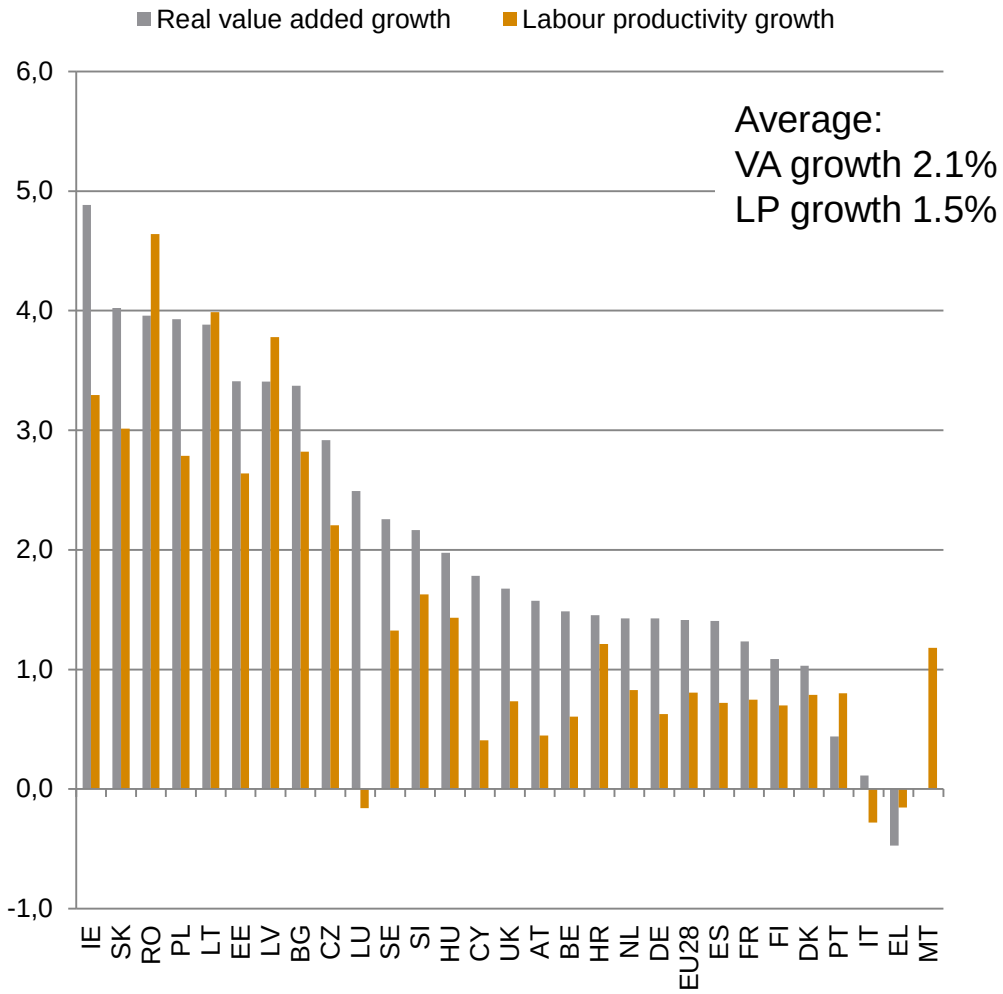


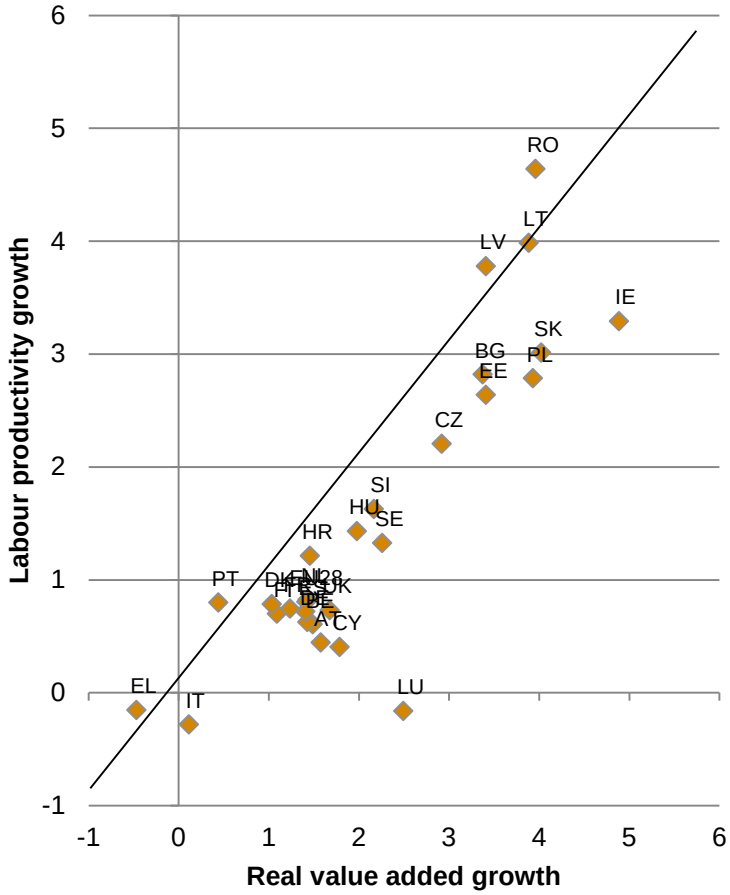
Source: Eurostat NA data.

- Growth rate of value added: 1.40%
- Growth rate of labour productivity: 0.78%

Value added and labour productivity growth rate

2002-2015, in %





When does demography kick in?

Results from a simple trend model

A simple trend accounting

- Labour supply depends on change in activity rate a_t and growth of working age population N_t

$$S_t = [a_0(1+\alpha)^t][N_0(1+n)^t]$$

with logistic trend of activity rate [here: approximated by constant growth]

- Labour demand E_t depends on growth of GDP Y_t and growth of labour productivity L_t

$$E_t = \frac{Y_0(1-y)^t}{L_0(1-\lambda)^t}$$

- Some manipulations lead to approximate **threshold year** given by

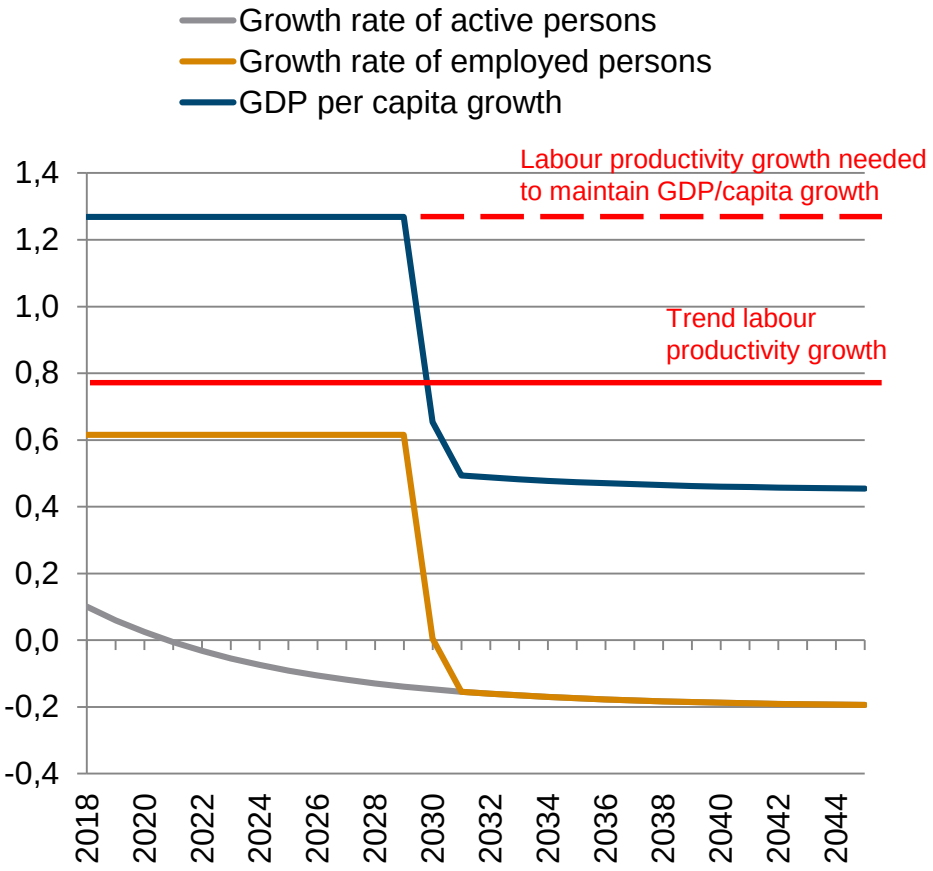
$$t^* \approx \frac{(A_0 - E_0)/E_0}{[y-(n+\alpha+\lambda)]}$$

where A_0 is active population and E_0 i s employed population in the benchmark year

Dynamics

If labour supply is exhausted, economic growth falls back to growth rate of labour supply and technology

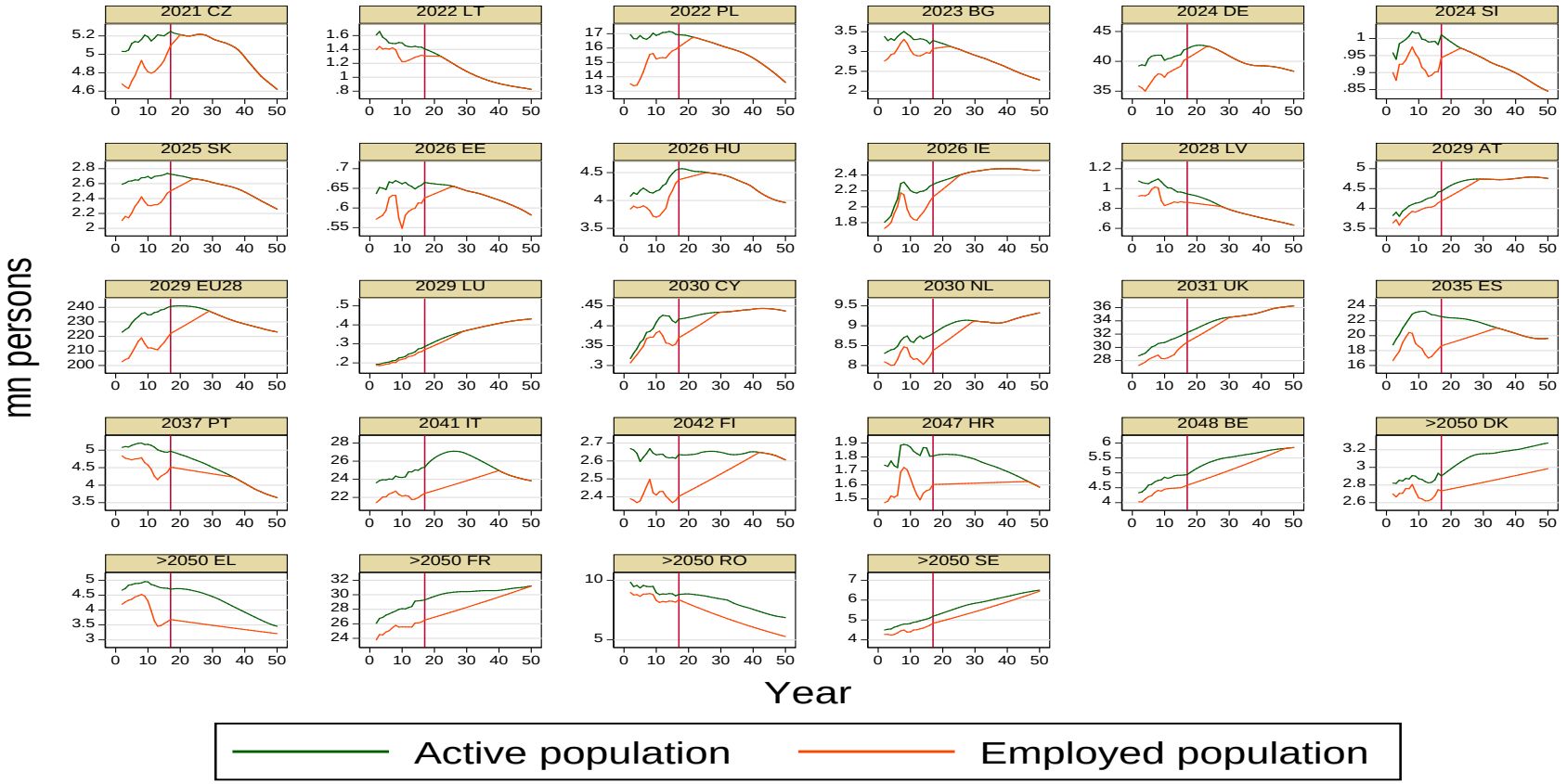
After threshold is reached, GDP/capita grows at slower rate. Labour productivity would have to increase to compensate for lower overall growth.



Source: Own calculations.

Dynamics by country (baseline scenario)

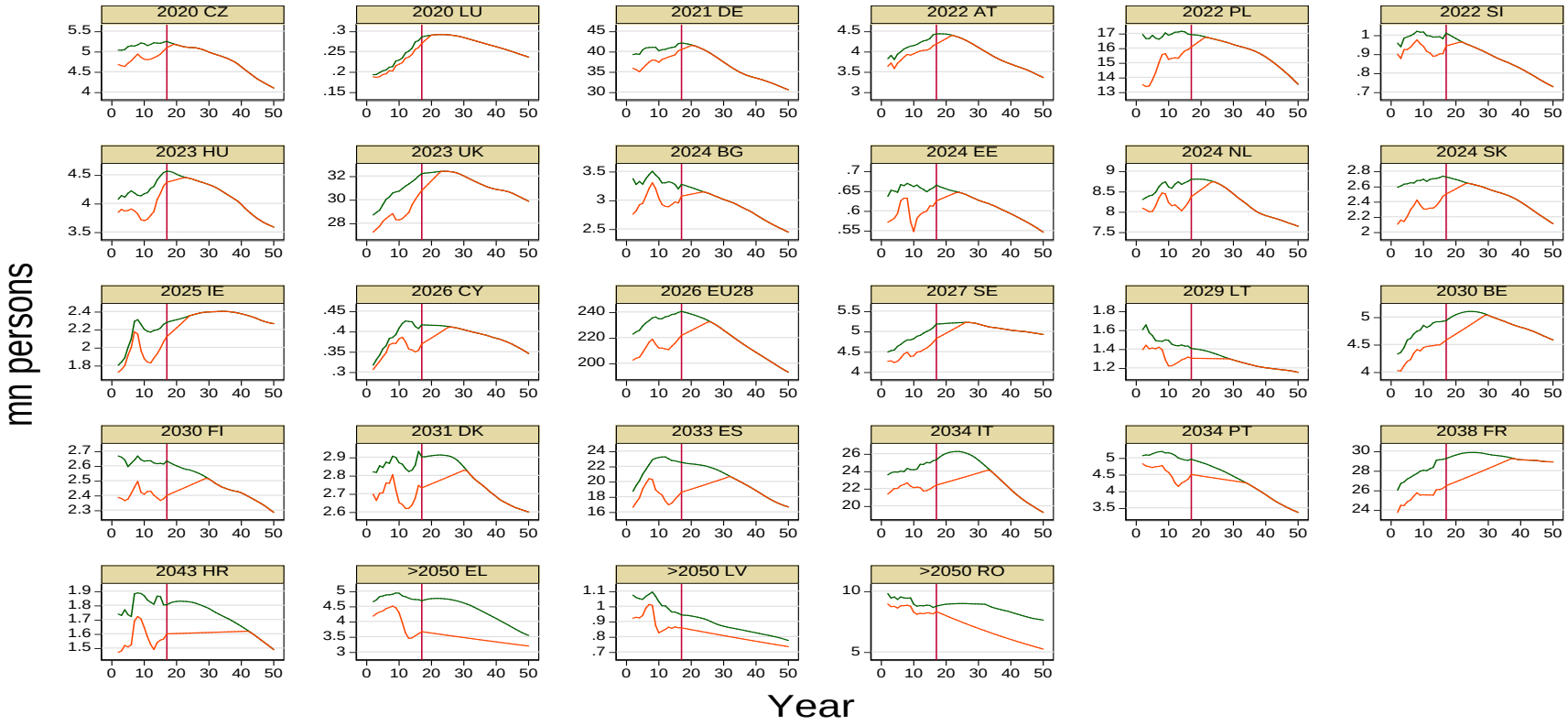
(preliminary results)



Note: Actiity rate assumed to be 75%
Source: Own calculations.

Dynamics by country (no migration scenario)

(preliminary results)



Note: Actiity rate assumed to be 75%
Source: Own calculations.

Messages

- At some point in time growth regime might become labour constrained
  - If not ‚saved' by higher productivity growth rates
  - Though note correlation with GDP growth
- Turnaround might occur relatively quickly (at least in some countries)
  - Emerging labour shortages can no longer be compensated
- Impacts also negatively on GDP/capita growth
  - Note: Total population is still growing slightly (or constant, or declining slower than working age population)
- Questions
  - Can labour productivity accelerate to such an extent that economic growth can be sustained (in total or in per-capita terms)?
  - Can robotistation and ICT capitalisation spur labour productivity growth?

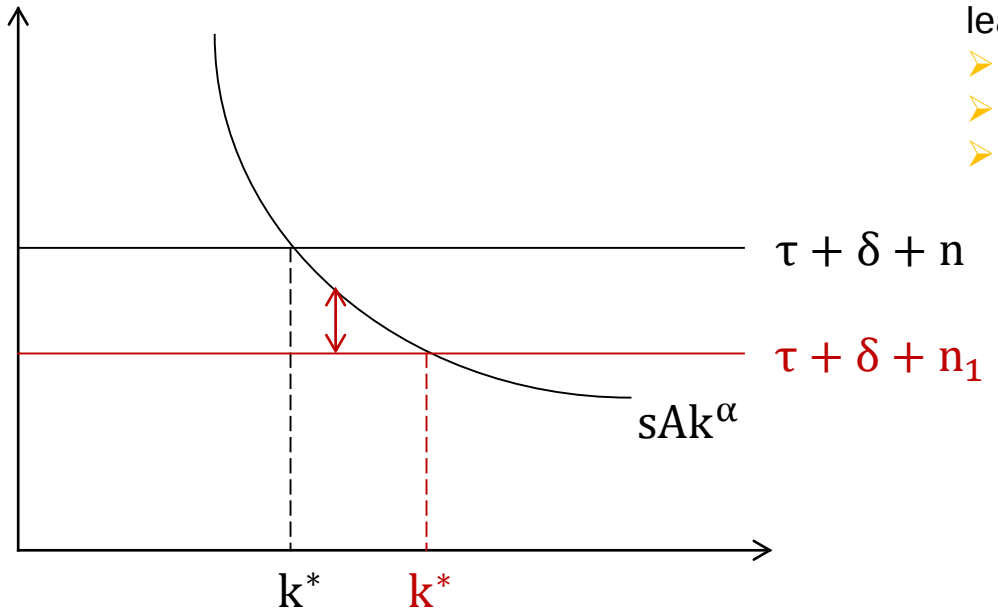
Growth theories in the light of a declining population

Solow model

- Per labour variables do grow at the rate of exogenous technical change

$$g = \tau$$

- Level variables grow at rate $n + \tau$



A reduction in population growth leads to

- lower growth of level variables
- a higher capital-labour ratio
- a period of higher growth rates in the transtion from high to low population growth

Solow model with automatization capital

- Cobb-Douglas production function

$$Y(t) = AK(t)^{\alpha}[L(t) + P(t)]^{1-\alpha}$$

where L and P (automatisation capital) are perfect substitutes

- In an internal equilibrium

$$P(t) = \frac{1-\alpha}{\alpha} K(t) - L(t)$$

and

$$Y(t) = \left(\frac{1-\alpha}{\alpha}\right)^{1-\alpha} AK(t)$$

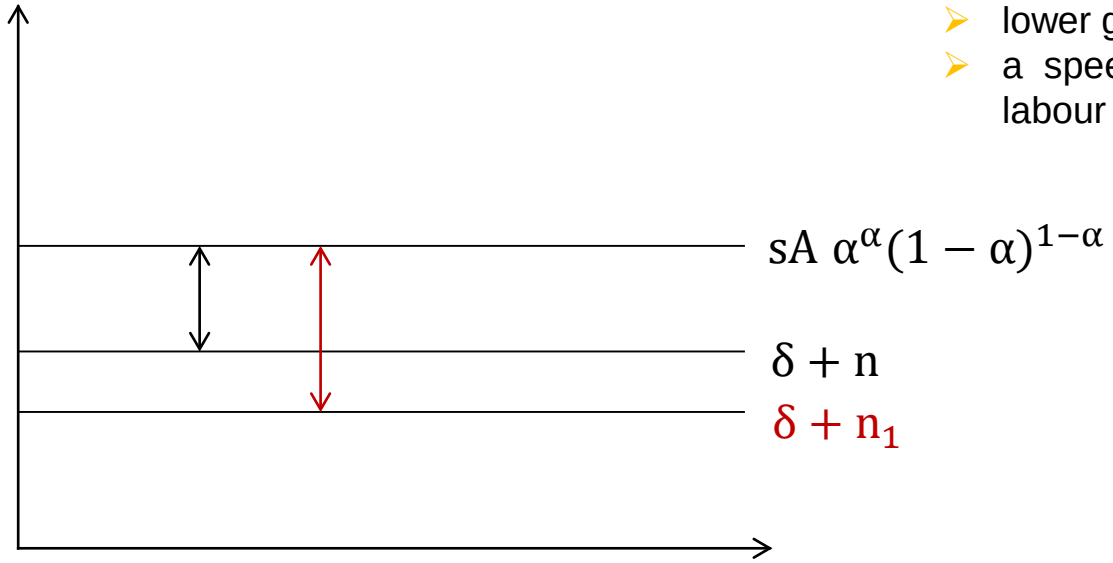
Solow model with automatization capital

- All per capita variables grow at (derived from Cobb-Douglas PF)

$$g = sA\alpha^{\alpha}(1-\alpha)^{1-\alpha} - \delta - n$$

- A lower growth rate of (working-age) population leads (ceteris-paribus) to a higher growth rate!

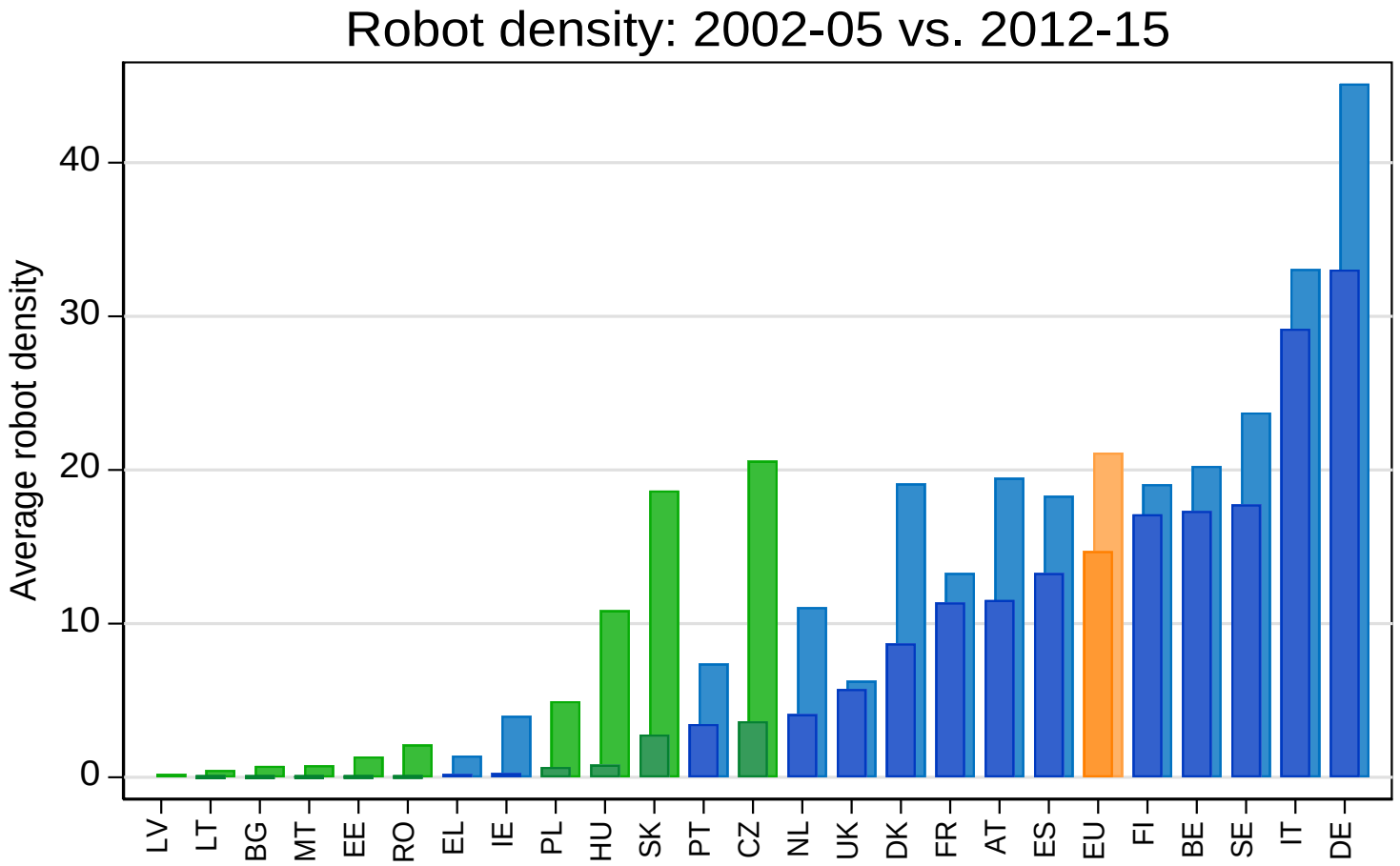
A reduction in population growth leads to
- lower growth of level variables
- a speeding up of capital-labour ratio growth



Can ICT capitalisation and robotisation compensate for the decline in labour supply?

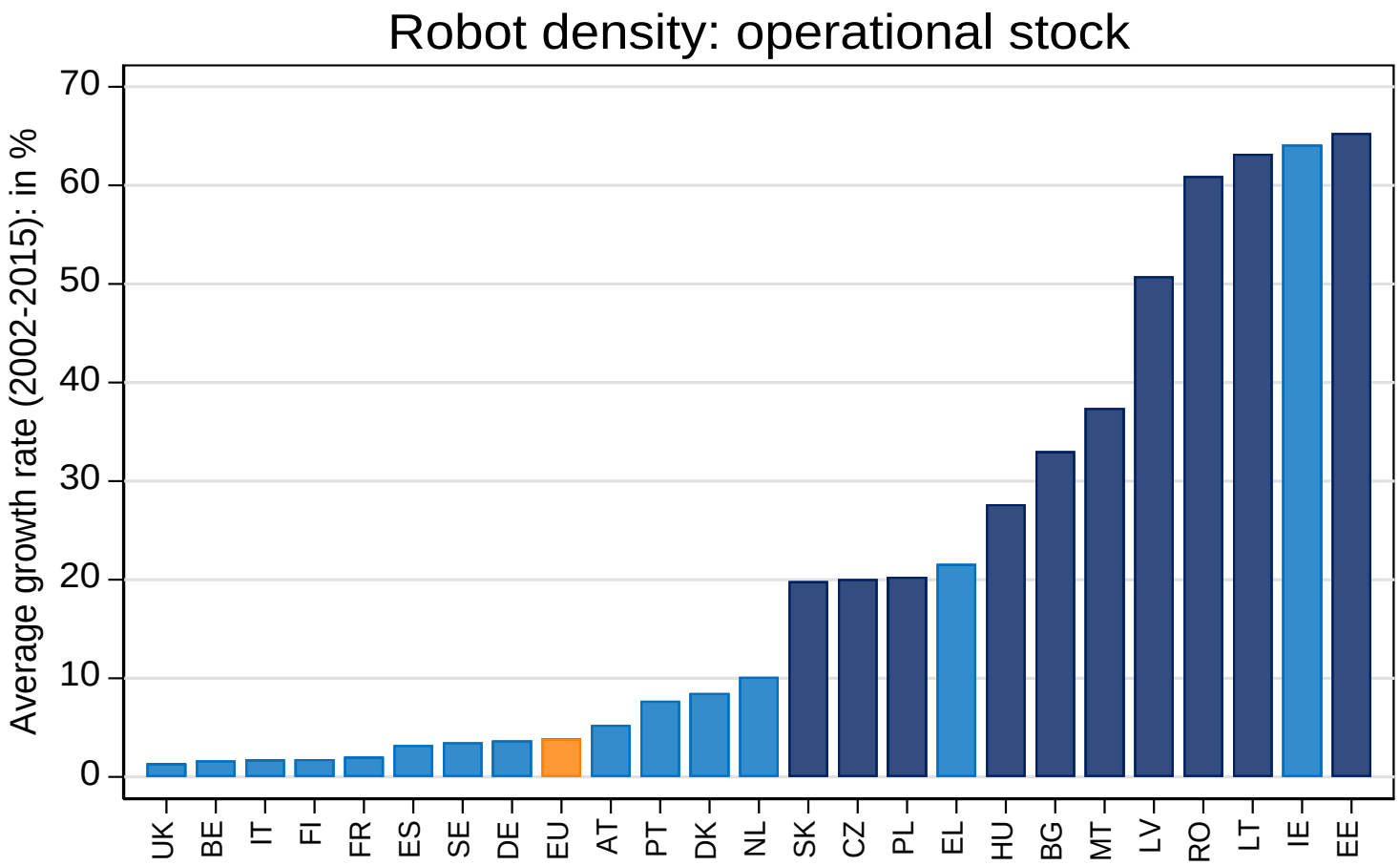
Some stylized facts

Some stylized trends



Source: World Robotics Statistics Database and EU-KLEMS (2017 release)
Note: Robot density defined as the number of robots per 10,000 employees

Some stylized trends



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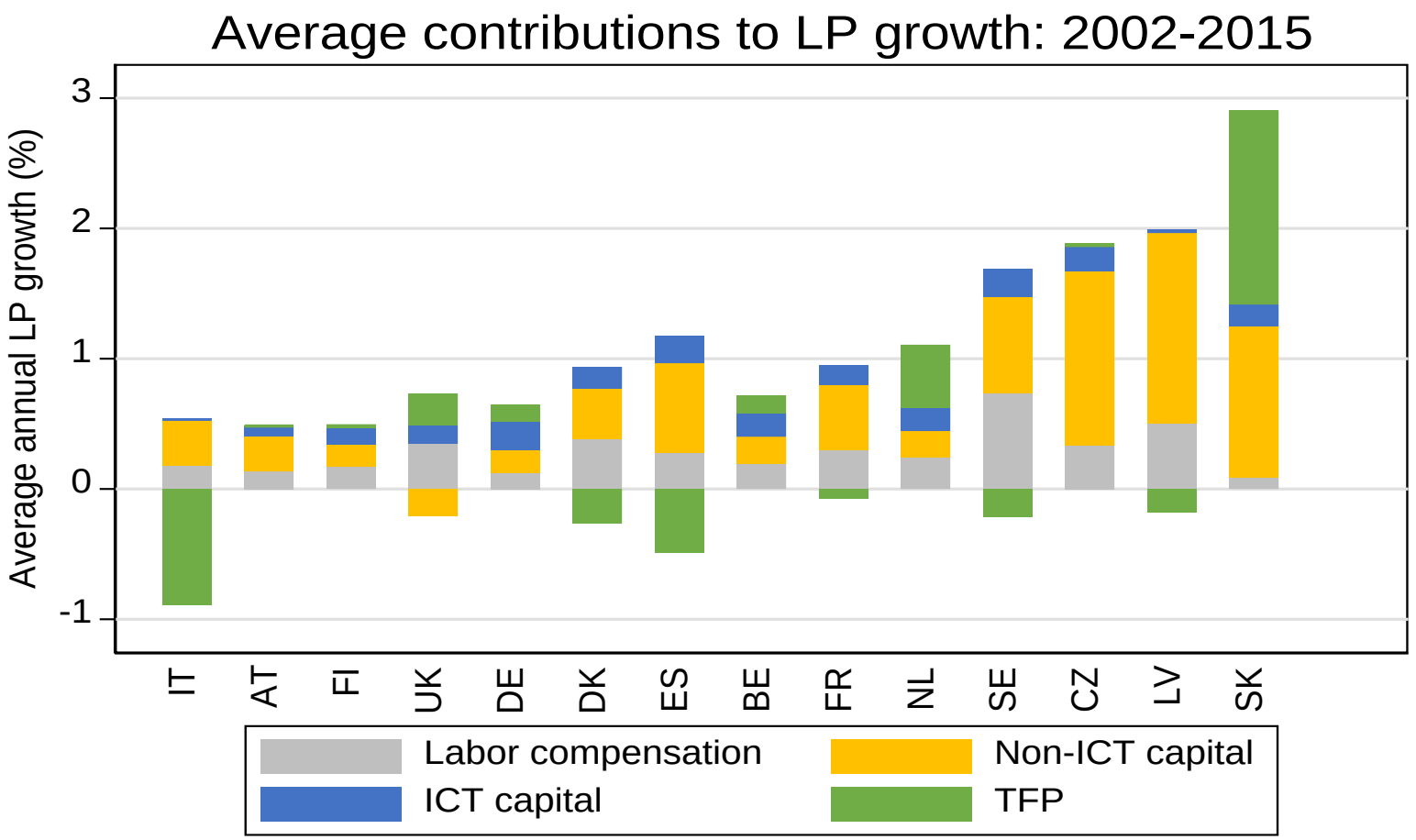
Some stylized trends



Source: EU-KLEMS (2017 release), wiiw calculations.
Note: Total economy

Question to be addressed

- By how much must digitisation and robotisation increase to compensate for the demographic decline?
- How strong does the productivity effect have to be to compensate for the demographic decline?
- Decoupling of productivity and GDP growth?
  - Need strong productivity growth at constant GDP growth
  - => GDP/capita growth constant
  - => Labour productivity growth compensates decline in labour supply
- Work in progress: Various regression approaches
  - Impact of robots on productivity
  - Impact of labour shortages on robots or capitalisation and on productivity
  - Changes in relationship between labour productivity and GDP growth

(Preliminary) Conclusions

- Strong negative demographic trends in parts of Europe
  - mostly in CEE, but also many other economies in the longer run
- Various signs of strong (and persistent) labour shortages
- Trends of increasing robotisation and capialisation (in accordance with standard growth theories)
- However, the latter are unlikely to (fully) compensate for the decline in labour supply in countries with strong demographic pressures
- Interesting theoretical implications ...

Thank you for your attention!

Please follow us on:

Robert.Stehrer@wiiw.ac.at
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Appendix

Growth theories in the light of a declining population

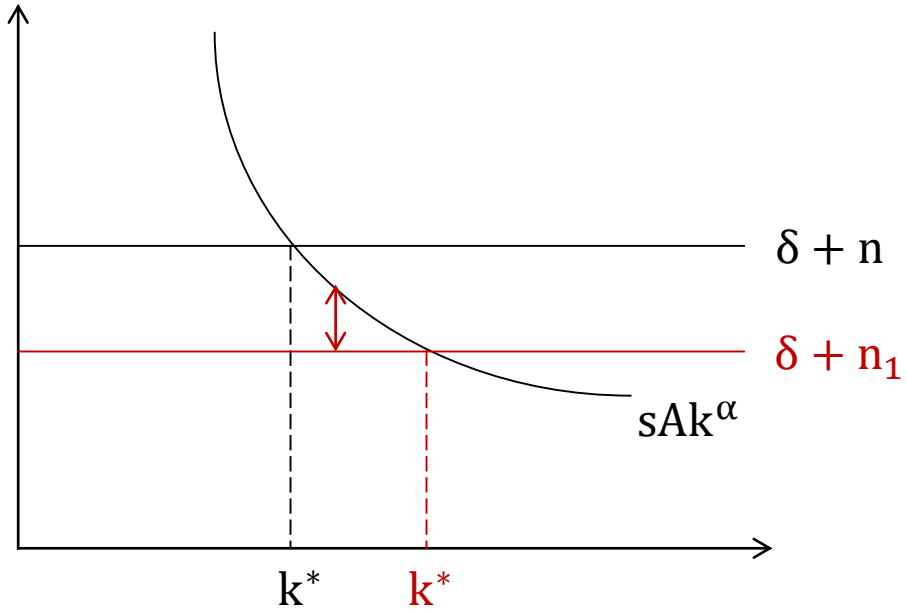
Solow model

- Per labour variables do not grow

$$g = 0$$

without (exogenous) technical progress

- Level variables grow at working-age population growth rate n



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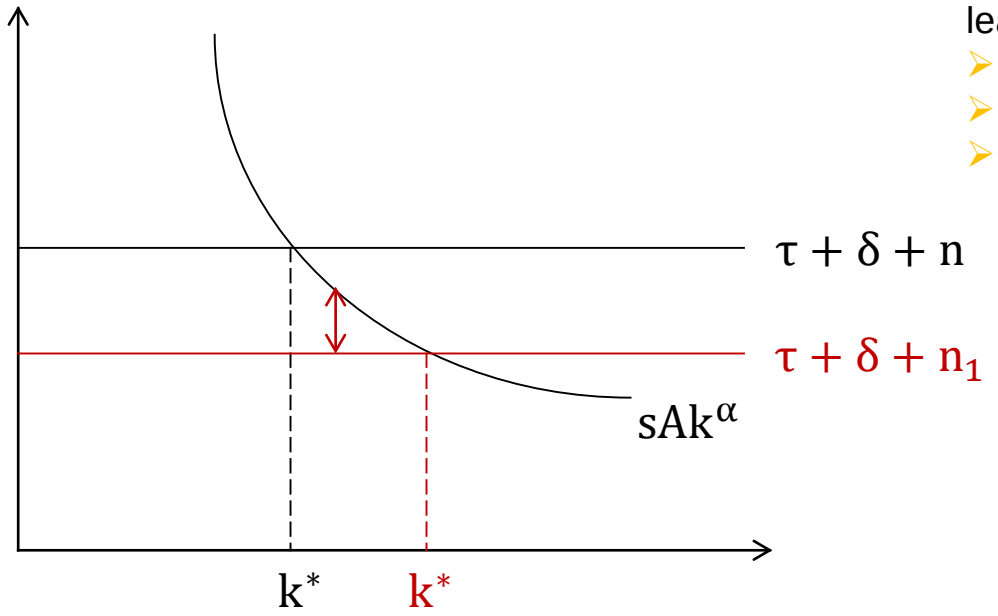

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Solow model

- Negative working age population growth $n < 0$ implies negative total (level (e.g. GDP) growth rates (assuming that $\delta + n > 0$)
- As total population growth is zero, GDP/capita declines (‚ageing effect')

Exogenous technical change

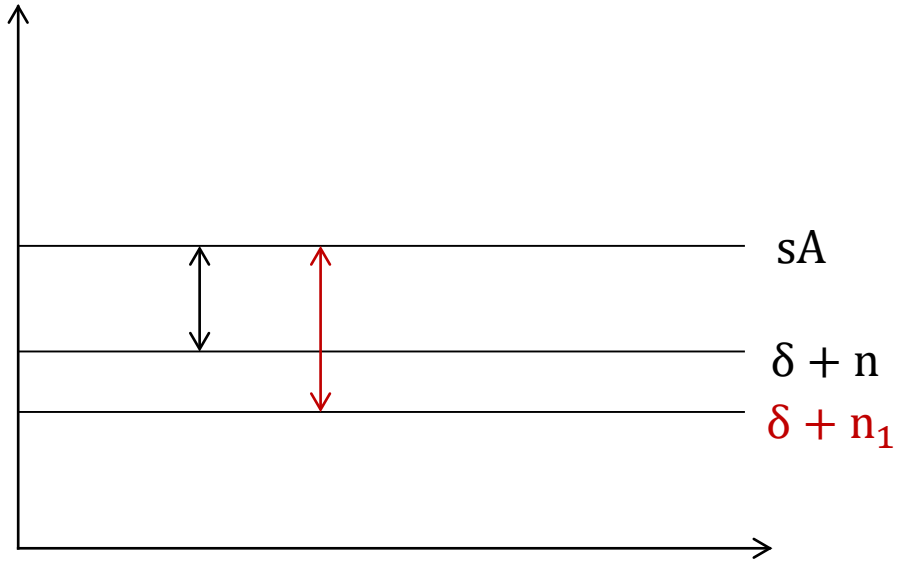
- $\tau + n > 0$
  - Growth rate of economy is $\tau + n > 0$
  - GDP/capita is increasing (but at lower pace)
- $\tau + n = 0$
  - Growth rate of economy is 0
  - GDP per capita is constant (if population growth is 0)
- $\tau + n < 0$
  - Growth rate of economy is negative
  - GDP per capita is declining (if population growth is 0)

AK model

- All per capita variables grow at

$$g = sA - \delta - n$$

- Economy is growing even without exogenous technical progress
- Higher population growth leads to lower per-capita growth
- Capital-labour ratio grows at constant rate g



A reduction in population growth leads to

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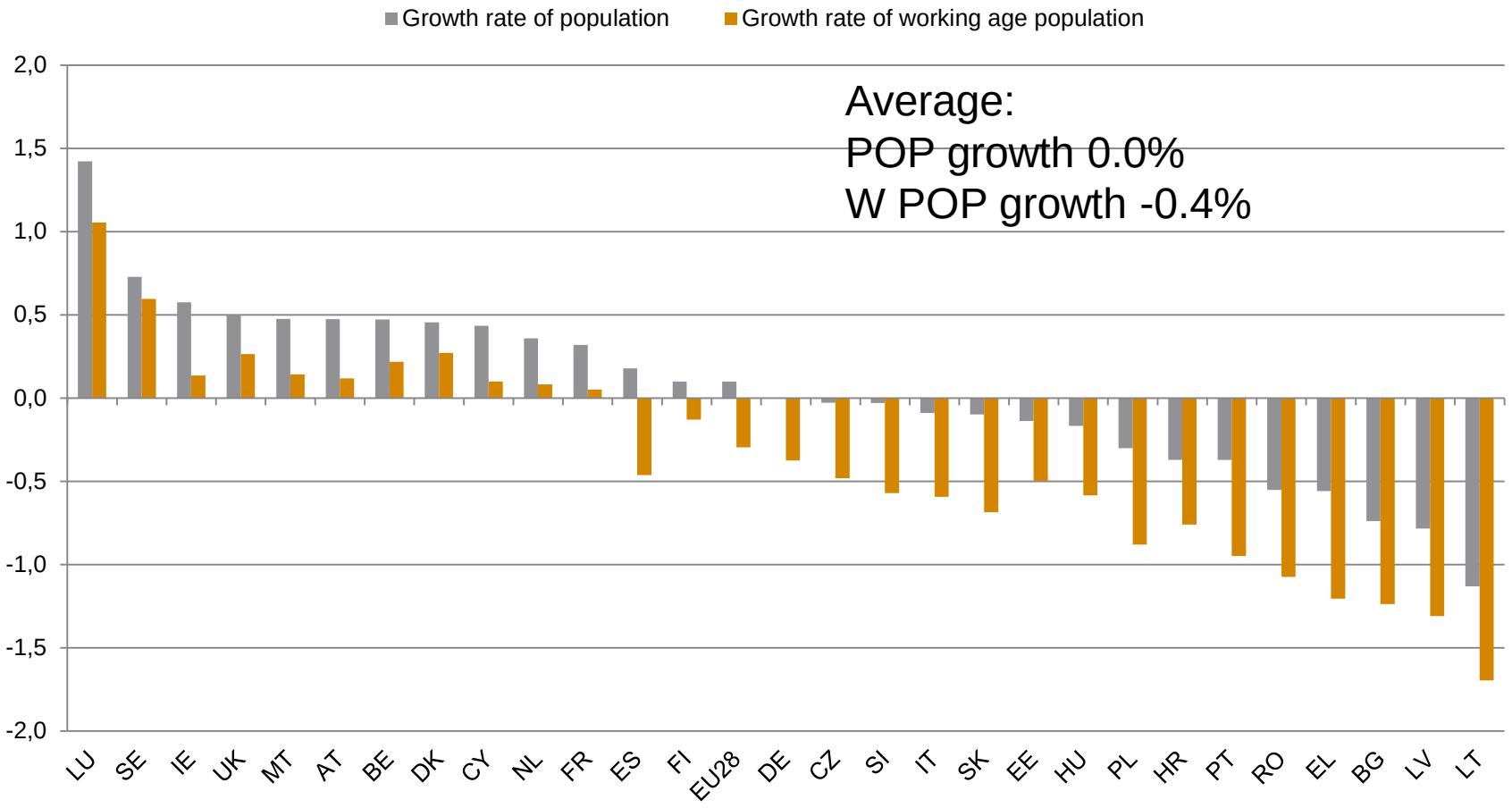
- a speeding up of capital-labour ratio growth

Appendix II
Additional data

Population growth



Illustrative benchmarking

Difference of activity to employment rate in %	8.3	8.3	8.3	8.3	8.3	8.3	8.3
GDP growth	1.40	2.00	1.40	1.40	1.40	1.40	1.40
Working age population growth	0.6	0.6	0.6	0.0	-0.2	-0.2	-0.2
Growth rate of activity rate	0.46	0.46	0.00	0.00	0.00	0.00	0.00
Growth rate of labour productivity	0.78	0.78	0.78	0.78	0.78	1.00	1.17
Year of threshold	54	11	13	13	13	21	36

Source: Own calculations.

Reflecting on the relationship

$$t^* \approx \frac{(A_0 - E_0)/E_0}{[y - (n + \lambda)]} = \frac{(A_0 - E_0)/E_0}{[(y - \lambda) - n]} = \frac{(A_0 - E_0)/E_0}{[(\rho\lambda - \lambda) - n]} = \frac{(A_0 - E_0)/E_0}{[(\rho - 1)\lambda - n]}$$

- If $A_0 - E_0 = 0$ then $t^* = 0$
- If $y = \lambda + n$ then $t^* \to \infty$
- Assume $A_0 - E_0 > 0$
  - If $\rho\lambda - n < 0$ then $\rho\lambda < n$ then $t^* < 0$
  - If n declines, then t^* is becoming positive
  - If n becoming negative then t^* is becoming smaller
  - A larger λ makes t^* larger (stronger productivity growth helps to compensate for decline in labour)
- However if ρ>1 (see evidence) a larger λ makes t^* smaller