

European Central Bank | Frankfurt/M., 20<sup>th</sup> January 2025  
*Workshop on the German economy*

# How demography weighs on potential output – answers and questions

Timo Hoffmann and Stefan Kooths



Answers  
(regarding participation rates)

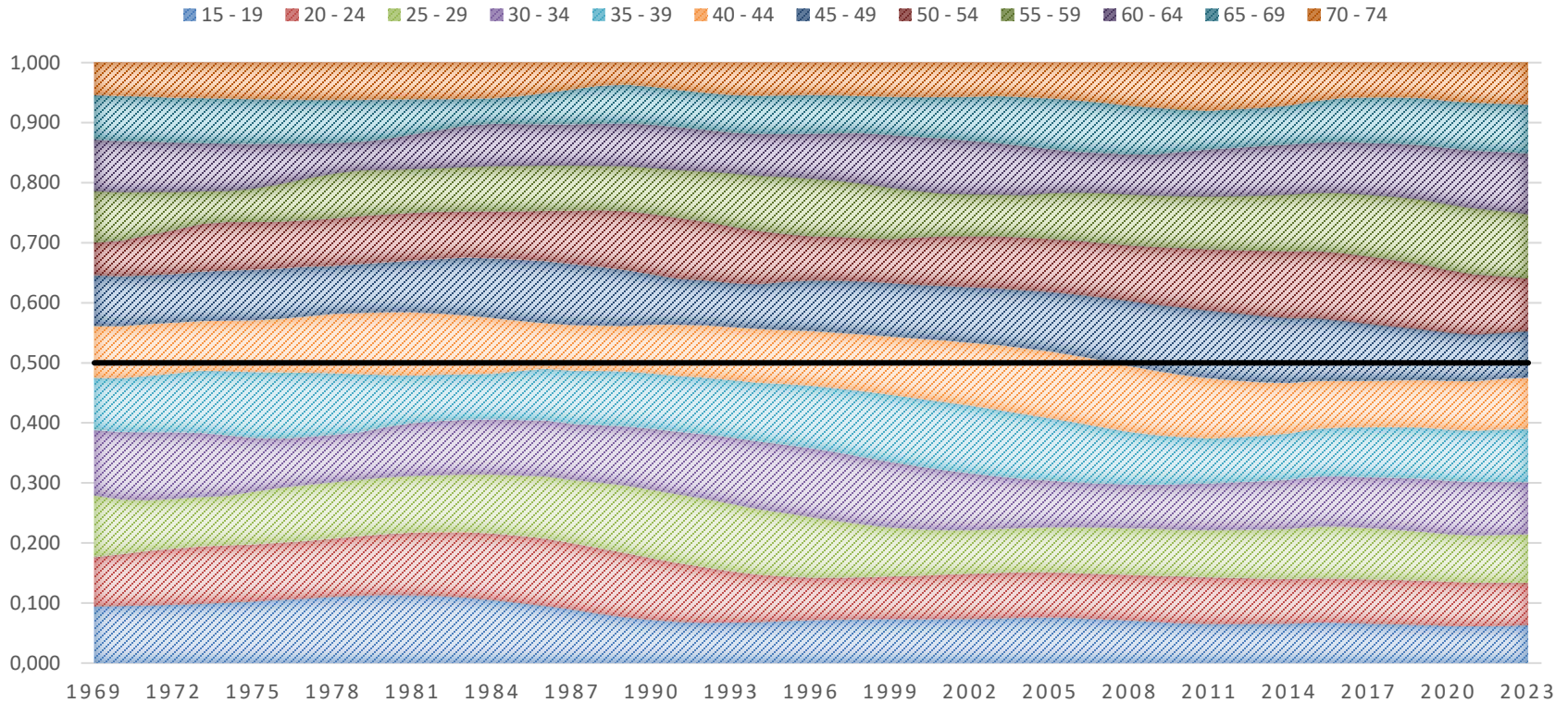
Questions  
(regarding other aspects)

# **Answers**

## **(regarding participation rates)**

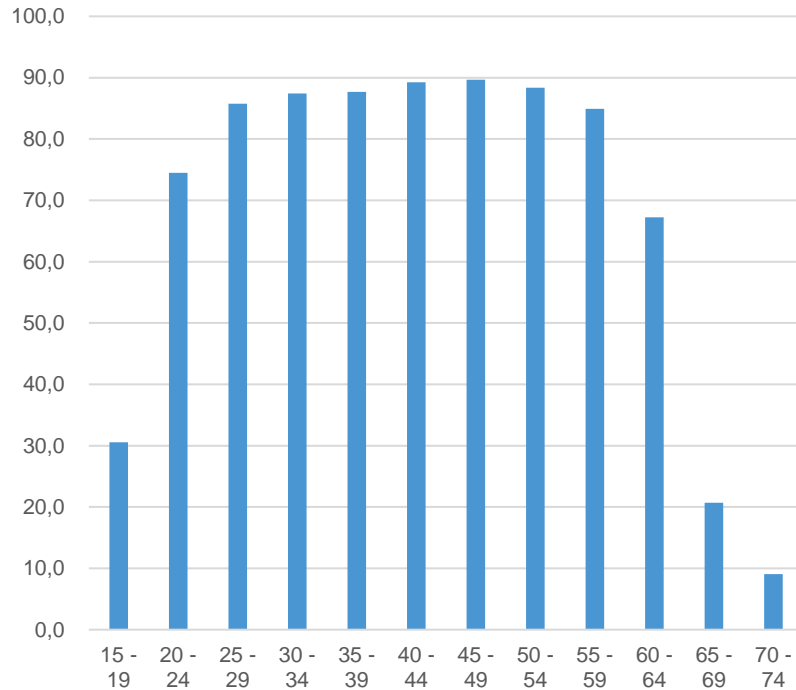
Questions  
(regarding other aspects)

# German working age population (1969-2023)

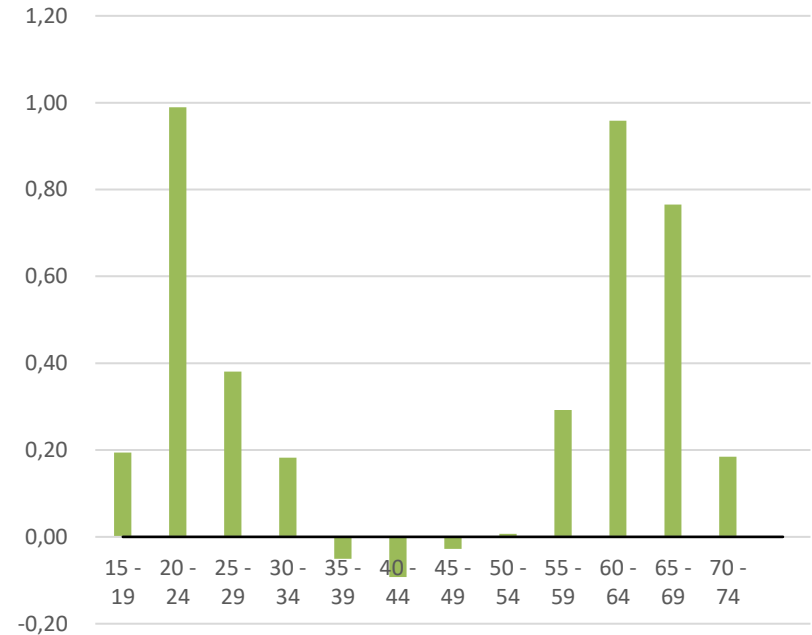


# Tails: Below-average + dynamic participation rates

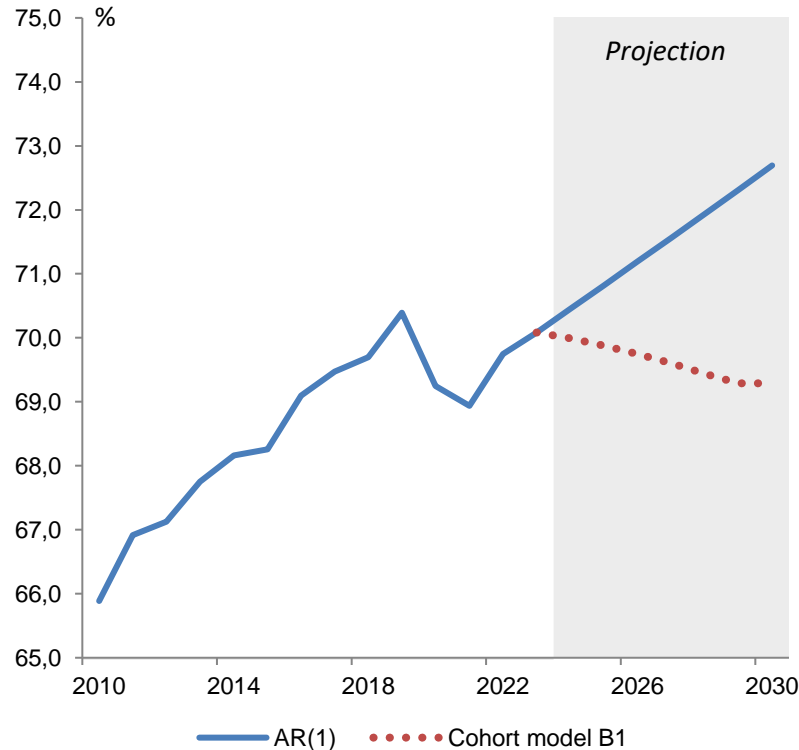
Participation rates in 2023



Participation rates, 5-years-slope in percentage points



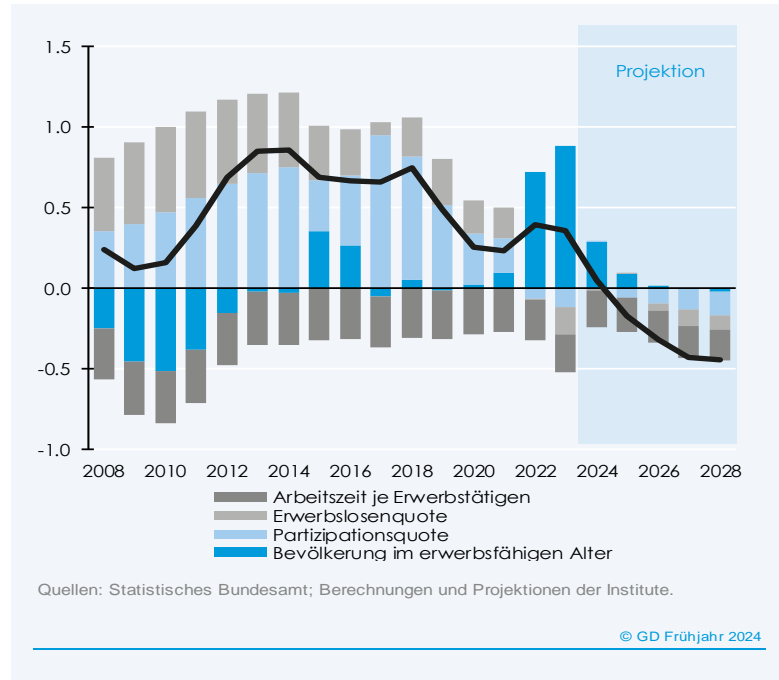
# Cohort-specific participation rates



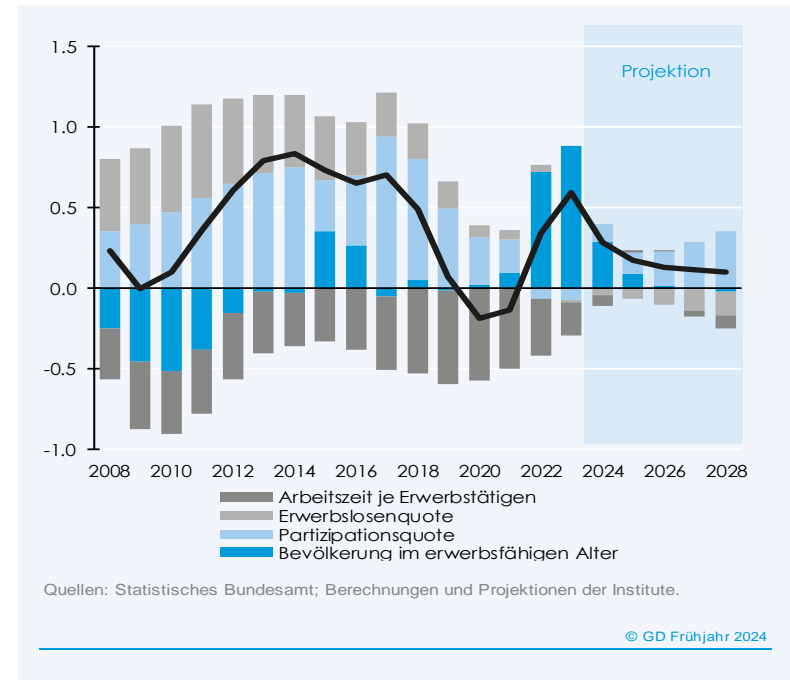
- Older age cohorts
  - » Increasing, but below-average participation rates
  - » Increasing population share
  - » Structural change (baby boomer effect) particularly strong in Germany
- Macro projections
  - » AR-1 leaves information unused
  - » Forecasting cohort-specific participation rates

# Impact on potential labor force projections

## MODEM: Age cohort model



## EU Method: AR(1)



# Forecasting participation rates: Specifications

<b>AR(1)</b>	Aggregate participation rate based on AR(1): $P_t = \beta P_{t-1}$
<b>Cohort model A</b>	Keeping participation rates fixed at most recent ex-post value (Pure population composition effect)
<b>Cohort model B1</b>	Cohort-specific rates based on recent 5-year trend
<b>Cohort model B2</b>	B1 but adjustment factor after short run horizon: $P_{k,t} = P_{k,t-1} + 0.8(P_{k,t-1} - P_{k,t-2})$
<b>Cohort model C</b>	Cohort-specific rates based on AR(1): $P_{k,t} = \beta_k P_{k,t-1}$
<b>Cohort model D1</b>	Cohort-specific rates based on transformed AR(1): $X_{k,t} = \beta_k X_{k,t-1}$
<b>Cohort model D2</b>	D1 but transformed AR(2): $X_{k,t} = \beta_{1,k} X_{k,t-1} + \beta_{2,k} X_{k,t-2}$
<b>Cohort model D3</b>	Change in cohort-specific rates based on transformed AR(1): $\Delta X_{k,t} = c + \beta_k \Delta X_{k,t-1}$

## Transforming participation rates

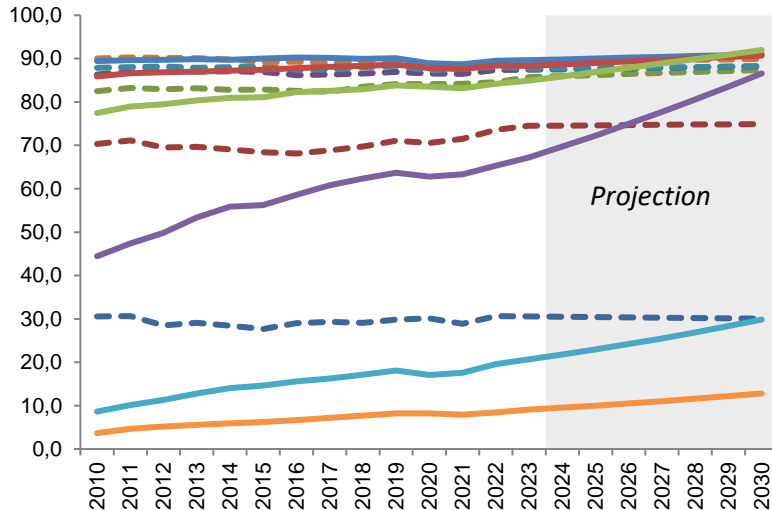
- Possible outcome: (long-run) projections (e.g. via ARIMA-models) turn out below 0 or above 100 percent
- Solution: Applying forecast models to transformed data
- Participation rates are between 0 and 1 like a cdf:  $P_t = F(X_t)$
- Thus, we fit a time series model for  $X_t = F^{-1}(P_t)$
- For example, AR(1):  $X_t = \alpha + \beta X_{t-1} + e_t$
- We finally obtain projections for the participations rate given by  $P_{t+h|t} = F(X_{t+h|t})$

# Cohort-specific participation rates

## Cohort model C

$(P_{k,t} = \beta_k P_{k,t-1})$

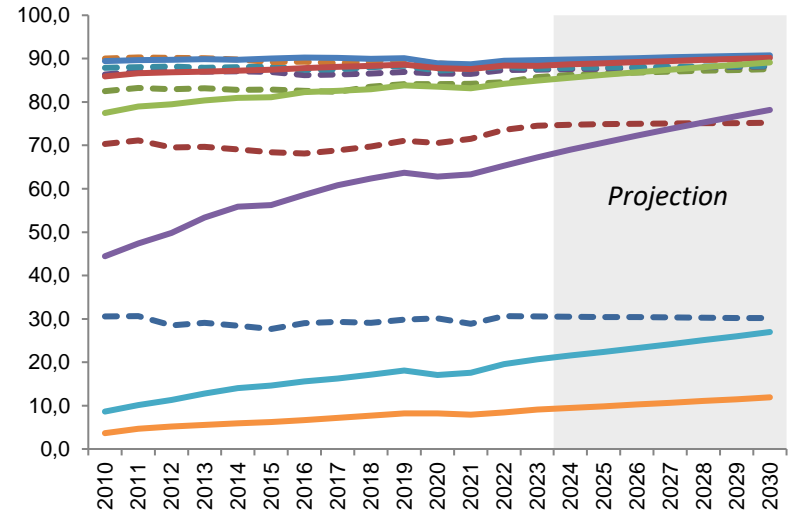
- 15 - 19    --- 20 - 24    --- 25 - 29    --- 30 - 34
- 35 - 39    --- 40 - 44    --- 45 - 49    --- 50 - 54
- 55 - 59    --- 60 - 64    --- 65 - 69    --- 70 - 74



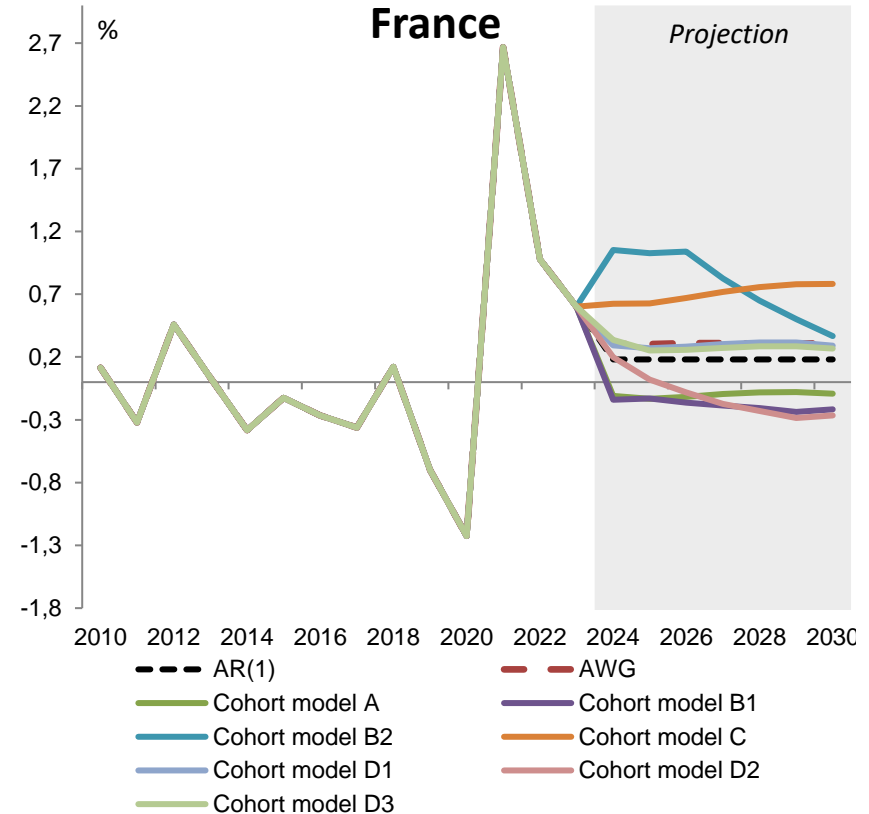
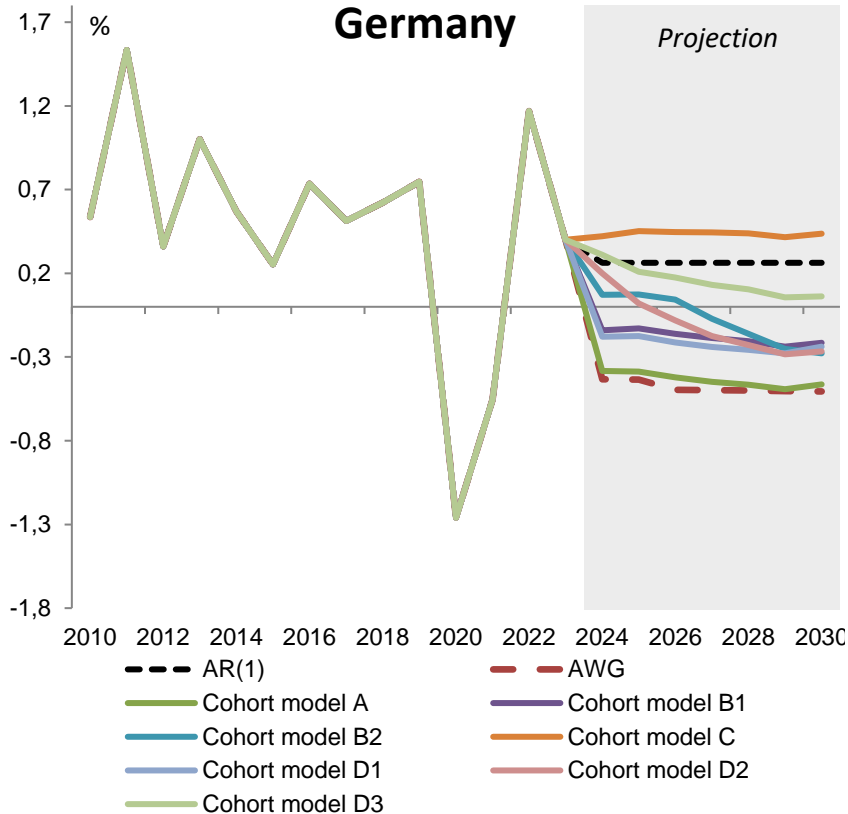
## Cohort model D3

$(\Delta X_{k,t} = c + \beta_k \Delta X_{k,t-1})$

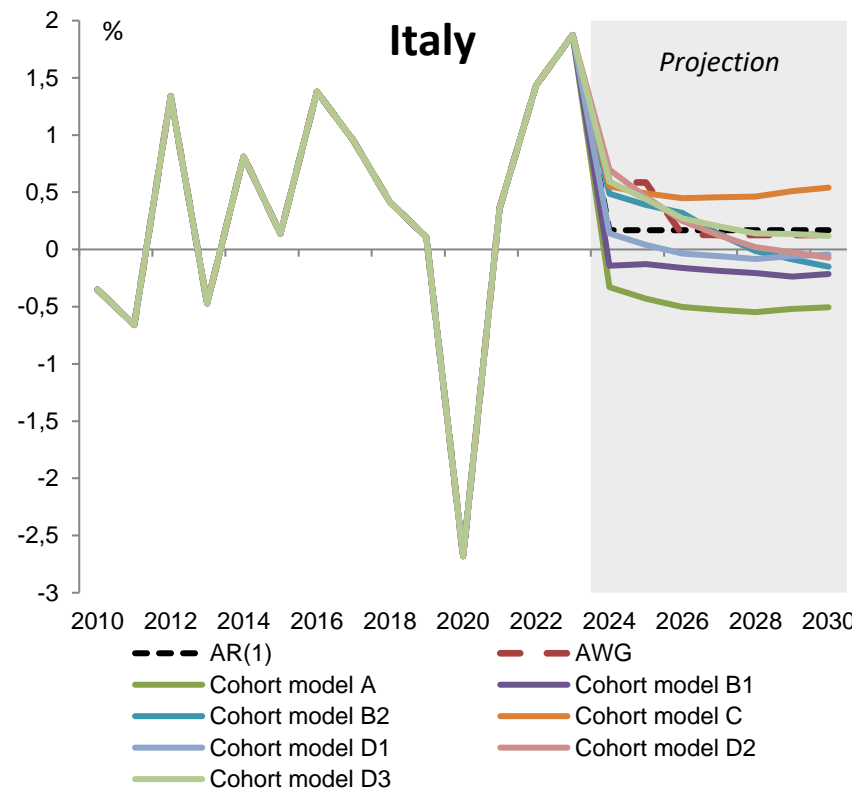
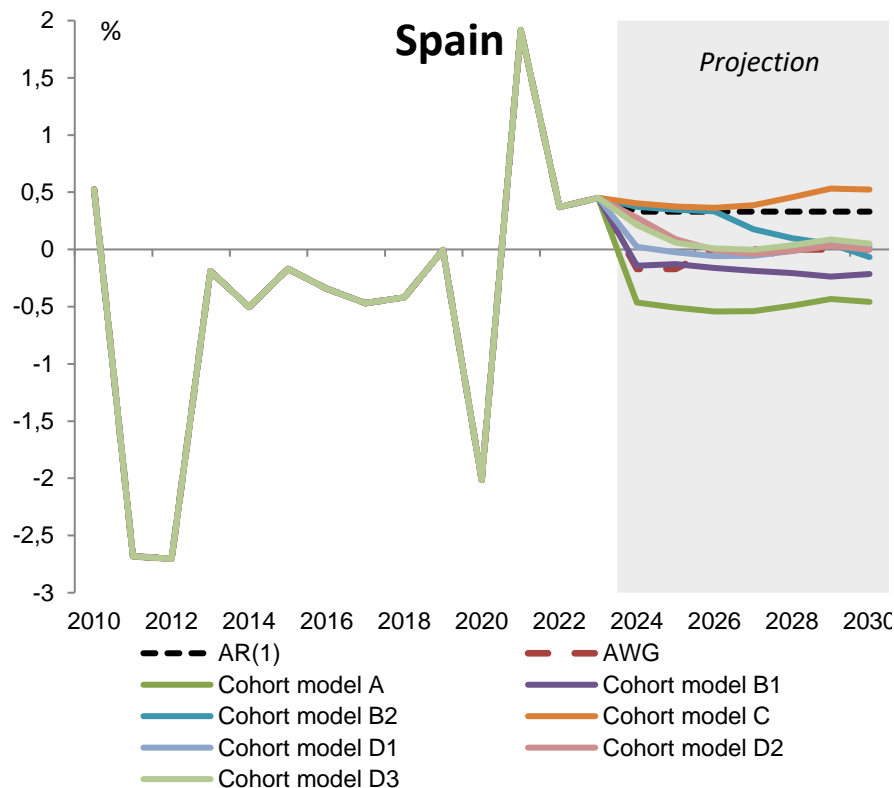
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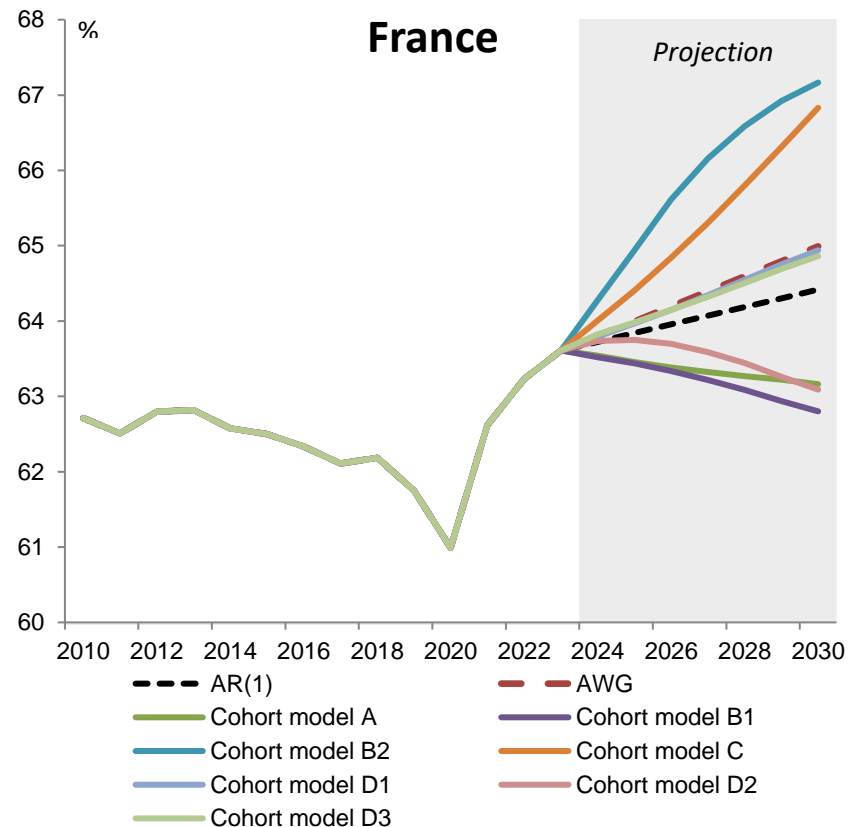
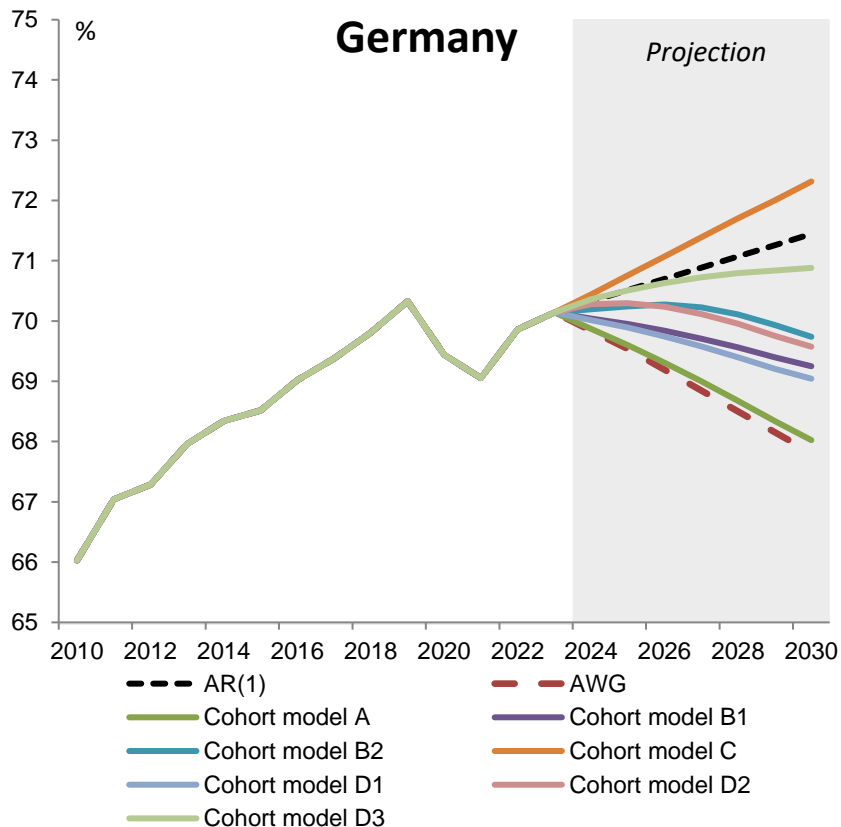
# Forecast: Annual change of aggregate participation rate



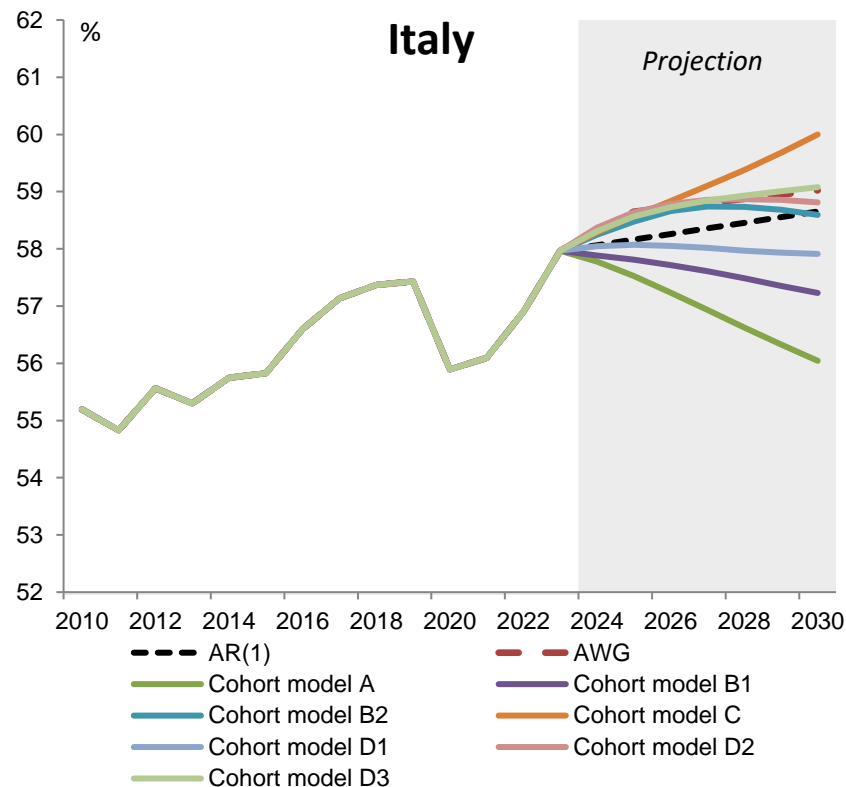
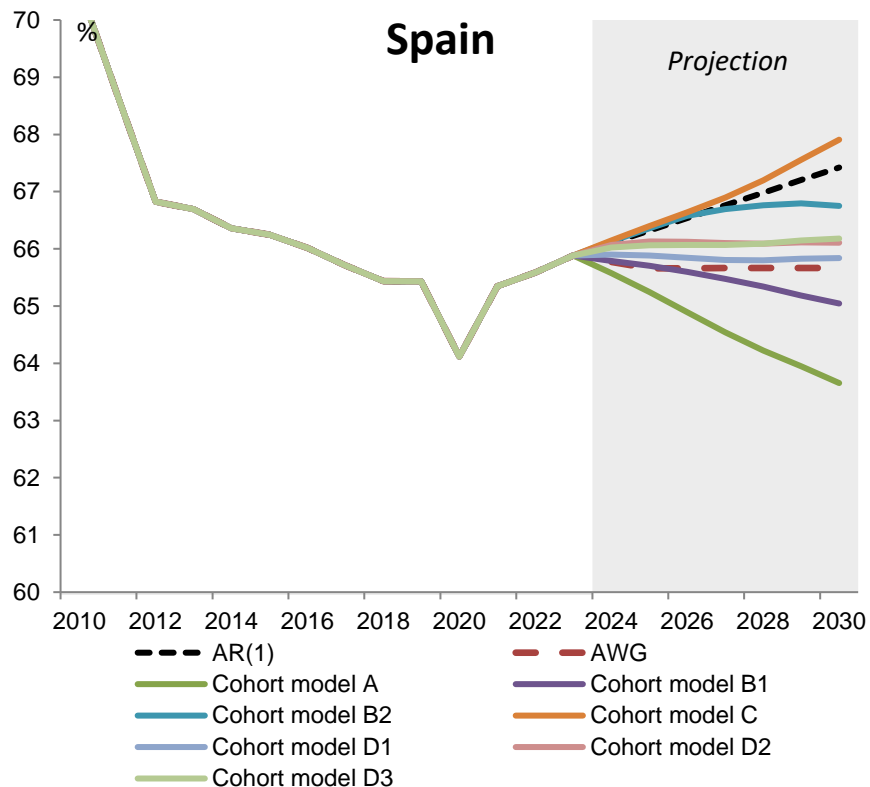
# Forecast: Annual change of aggregate participation rate



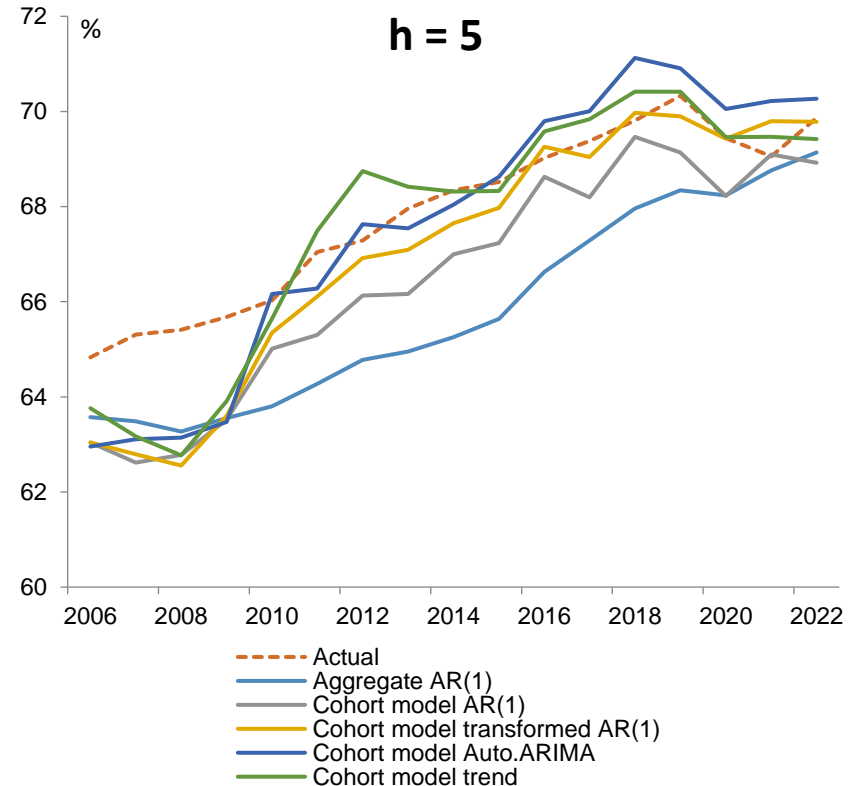
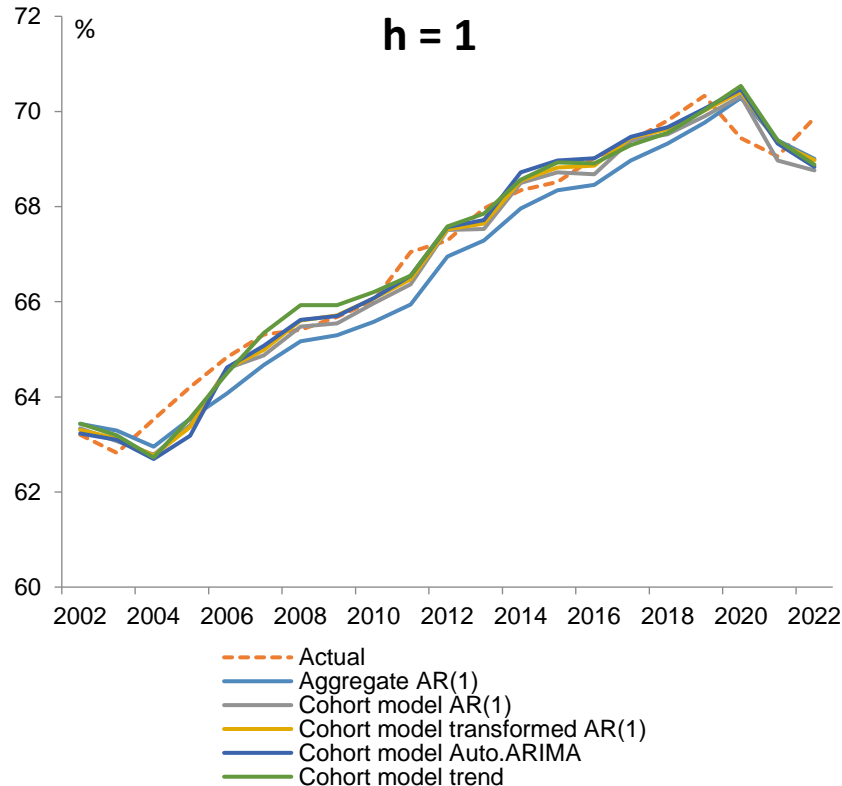
# Forecast: Level of aggregate participation rate



# Forecast: Level of aggregate participation rate



# Forecast results for Germany



# Forecast performance for Germany (I)

	h = 1	h = 2	h = 3	h = 4	h = 5
<b>Aggregate AR(1)</b>					
RMSE	0.58	0.98	1.35	1.75	2.16
<b>Cohort model: AR(1)</b>					
RMSE	0.47	0.72	0.92	1.23	1.53
Teil's U	0.82	0.73	0.68	0.70	0.71
p-value DM	0.06*	0.09*	0.13	0.23	0.28
<b>Cohort model: Transformed AR(1) (D3)</b>					
RMSE	0.45	0.65	0.84	1.04	1.24
Teil's U	0.77	0.66	0.63	0.59	0.57
p-value DM	0.03**	0.06*	0.14	0.19	0.21

# Forecast performance for Germany (II)

	h = 1	h = 2	h = 3	h = 4	h = 5
<b>Cohort model: Auto.ARIMA</b>					
RMSE	0.49	0.69	0.88	1.03	1.20
Teil's U	0.84	0.70	0.65	0.59	0.55
p-value DM	0.22	0.12	0.17	0.17	0.19
<b>Cohort model: 5-year trend with adjustment factor (B2)</b>					
RMSE	0.48	0.73	0.88	0.98	1.08
Teil's U	0.82	0.74	0.65	0.56	0.50
p-value DM	0.13	0.16	0.13	0.11	0.12
<p>*<math>p &lt; 0.1</math>, ** <math>p &lt; 0.05</math>, *** <math>p &lt; 0.01</math>  <i>T = 21 to T = 17 observations</i></p>					

# Conclusion

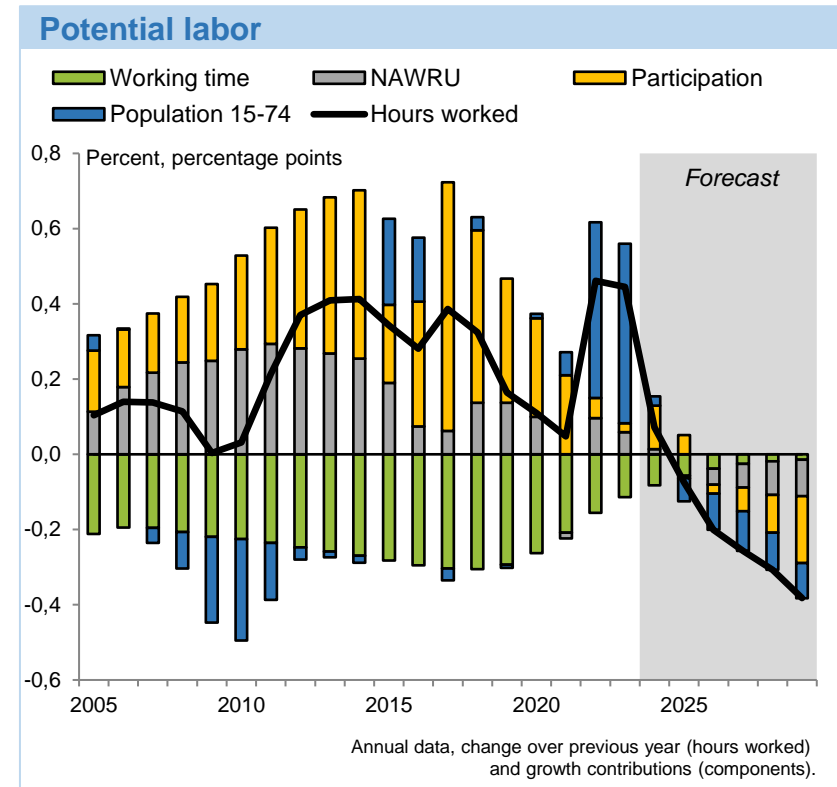
- Capturing demographic shifts by cohort models
  - » Not only improves the forecast performance in the past ...
  - » ... but currently tells a completely different story of the future (in particular, for the German economy)
  - ⇒ Significant influence on potential output
  - ⇒ More sources of uncertainty (more parameters)
- Vast range of cohort models
  - » Criteria: robustness, plausibility (long run!), forecast performance, simplicity, ...
  - » Transformed AR model seems to be a good choice
  - » Combination of models?
- Further improvements
  - » Distinguish between men and women
  - » Cohort-specific projection method

Answers  
(regarding participation rates)

**Questions**  
**(regarding other aspects)**

# Working time

- Cohort-specific approach (for the full picture)
- Work-life-balance
- Data limitations



Pressure on pension and healthcare system



Impact of an increasing tax wedge  
(in the absence of other reforms)

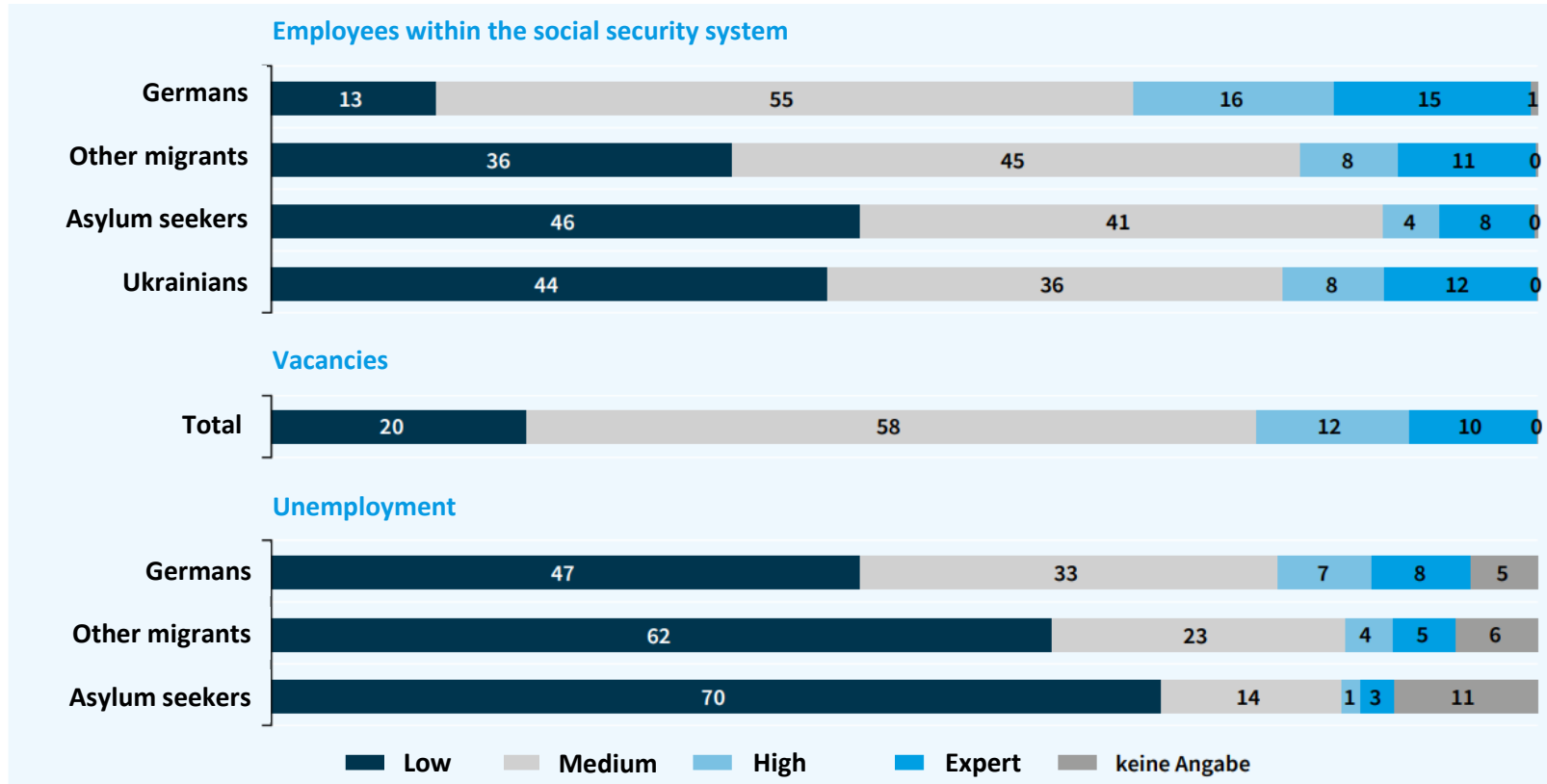
Supply-side:

Innovation capacity, adoption of new technologies,  
incentives for labor-saving technological progress

Demand-side:

Changing industrial structure

# Immigration and skill levels: Mismatch problem



# From quantity to quality

Human capital instead of hours worked

# Q&A



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