

Economic and Labour Market Impacts of Migration in Austria: An Agent-Based Modelling Approach

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Outline

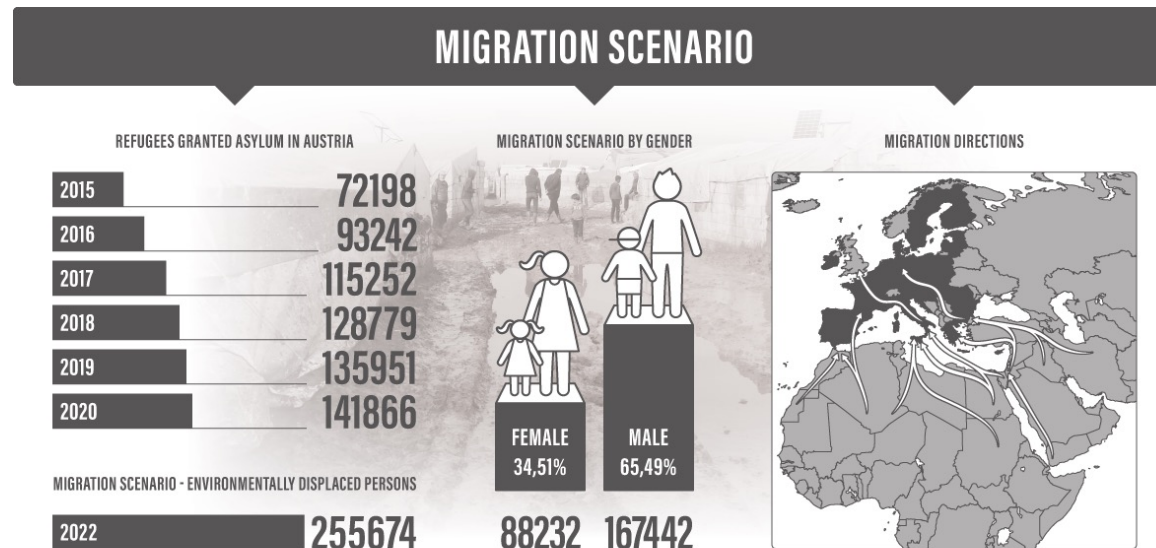
- Motivation
- Agent-based modeling of economic systems
- IIASA macroeconomic ABM
 - Overview and mechanisms
 - Calibration
- Simulation results

Economic effects of migration

- In Europe, **large migratory shocks** have led to a heated political debate on their management
- Uncertainty about the **migratory impact on the economy and society** has, in many instances, polarized the debate
- There is a **need for tools** to inform stakeholders and policymakers of the most likely economic and social consequences of migration



- Investigation of the **economic consequences** (GDP, government debt, unemployment rate, wages, social benefits) of an extreme **migration scenario** for **Austria**
- Consider **social heterogeneity** (e.g., by economic sector and socioeconomic status) to allow studying **distributional impacts**
- Make use of **detailed microdata**



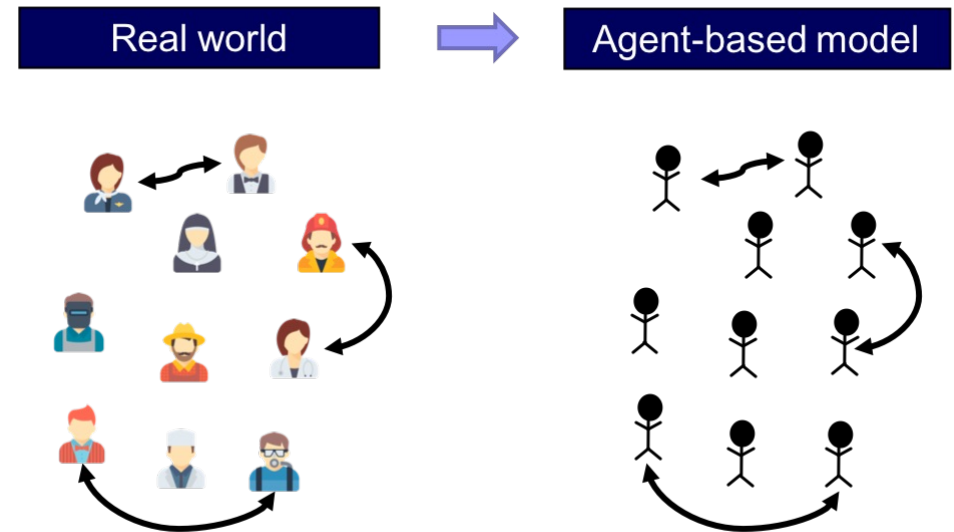
Agent-based modeling of economic systems

Agent-based models (ABMs) are **computer simulation models** with the following features:

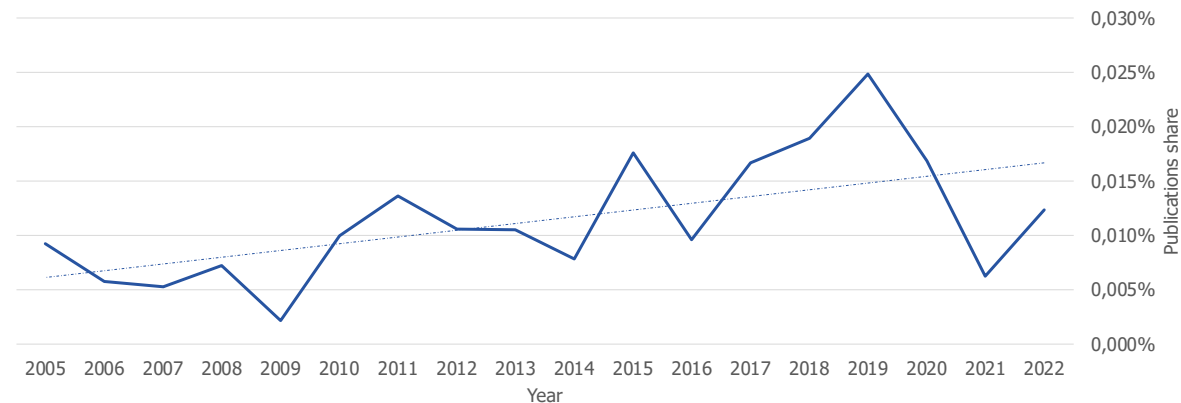
- They model **individual agents** and their individual **decisions** (decentralized decision-making)
- Can include thousands or even **millions** of agents
- Can capture **bounded rationality** (often in the form of some heuristics)
- Depict **emergent patterns** from micro-processes that aggregate to a macro level: the economy as a **complex system** subject to **fundamental uncertainty**

ABM is a (relatively) **new** way to model complex systems

ABMs have potential to be "**more realistic**" models of socioeconomic systems

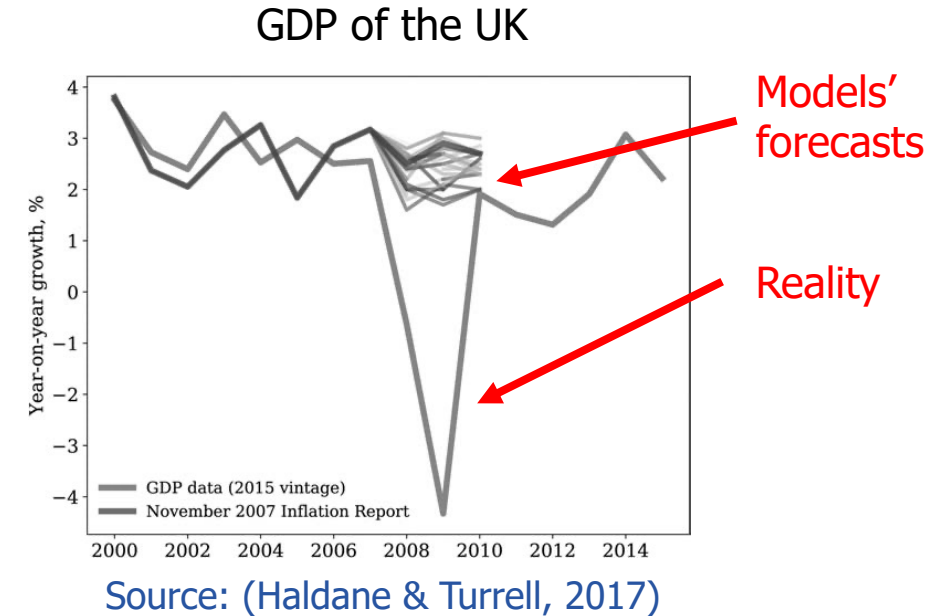


Share of publications indexed in Scopus for the search request TITLE-ABS-KEY ("*econom* agent-based" OR "agent-based *econom*") in the total number of publications in the "Economics, Econometrics and Finance" research area



Why ABM for economic systems?

- It seems that standard economic models perform rather well for “normal” times and not so well in “abnormal” times
- Many models currently used by central banks and large international institutions had “difficulty explaining both the depth and the slow recovery of the Great Recession.” (Lindé, Smets & Wouters, 2016)
- More generally, “... ABMs are a promising complement to the current crop of macroeconomic models, especially when making sense of the types of extreme macroeconomic movements the world has witnessed for the past decade.” (Haldane & Turrell, 2017)



- introducing **heterogeneous agents**
- relaxing **rational expectations**

Comparison of different types of economic models

Agent-based models explain the evolution of an economy by **simulating** the **micro-level behaviour** of **individual agents** to give a **macro-level** picture:

DSGE	TANK, HANK	ABM	ABM (next gen)
Representative agents	Heterogeneous agents	Heterogeneous agents	Heterogeneous agents
Log-linearized and solved numerically	Log-linearized and solved numerically	Solved numerically at the agent level	Solved numerically at the agent level
Rational or model-consistent expectations	Bounded rationality through myopia or limited foresight	Bounded rationality in expectations	Bounded rationality in expectations
Agents optimize given expectations	Agents optimize given expectations	Agents use simple heuristics	Agents use simple heuristics calibrated to micro & macro data
Match the historical evolution of variables	Match the historical evolution of variables	Reproduce stylized facts and generate endogenous business cycles	Reproduce stylized facts and match historical evolution of variables

"In principle it might even be possible to create an agent-based economic model capable of making useful forecasts of the real economy, although this is ambitious ... like climate modelling, [it's] a huge undertaking." (Farmer & Foley, 2009)

Comparison of different types of economic models

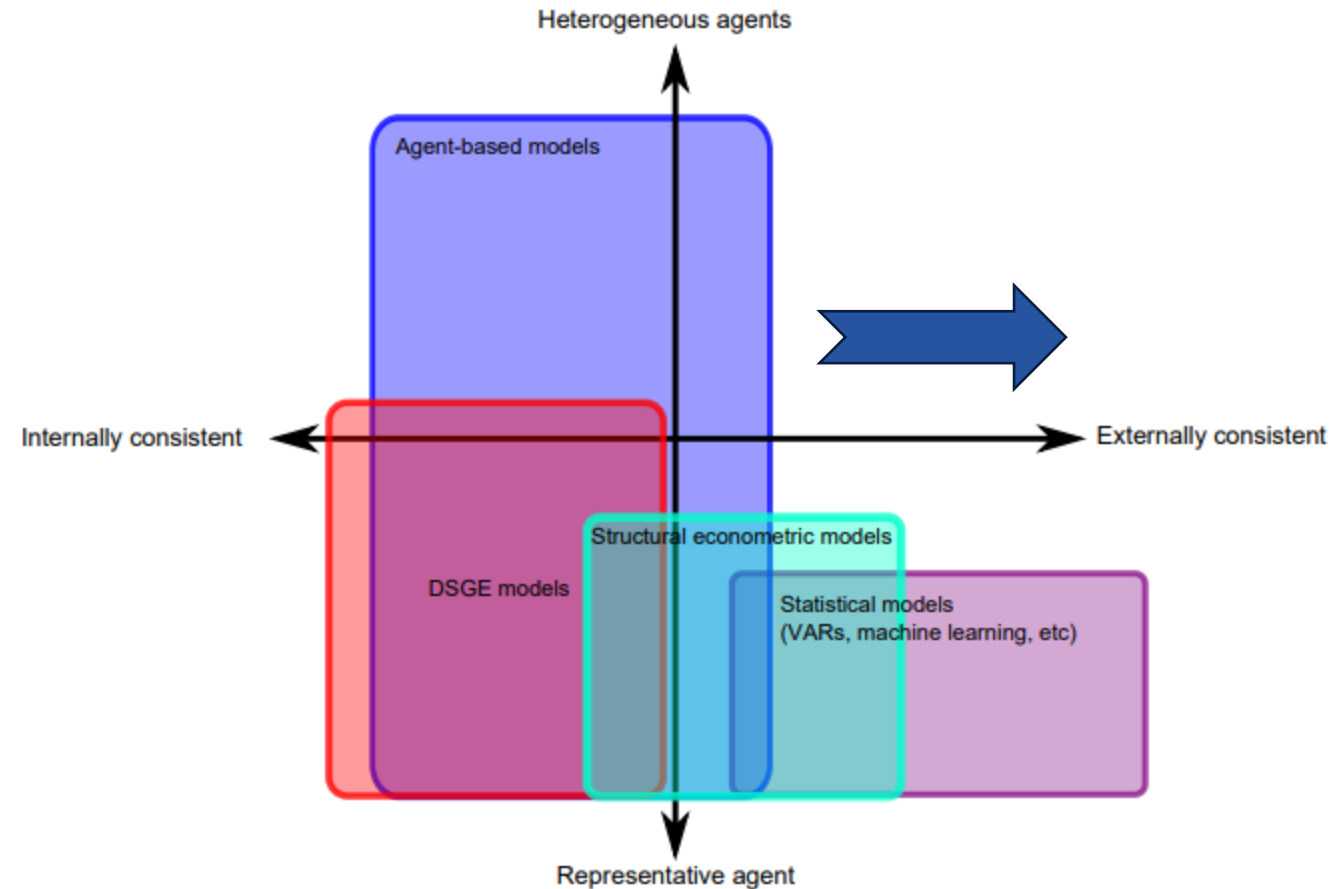


Figure 8. Macroeconomic ABMs may be thought of as lying within a wider modelling space, here shown as having two axes. Internal consistency is best represented by strongly microfounded behaviour, while external consistency is demonstrated by agreement with the data. On the other axis is the degree of agent heterogeneity which the model can include, with representative agents on one end and heterogeneity along many dimensions at the other. The within variation of each model type is likely to be larger than the variation between them, but the figure illustrates their approximate location within the wider modelling space.

Source: (Haldane & Turrell, 2017).

ABM for economic forecasting

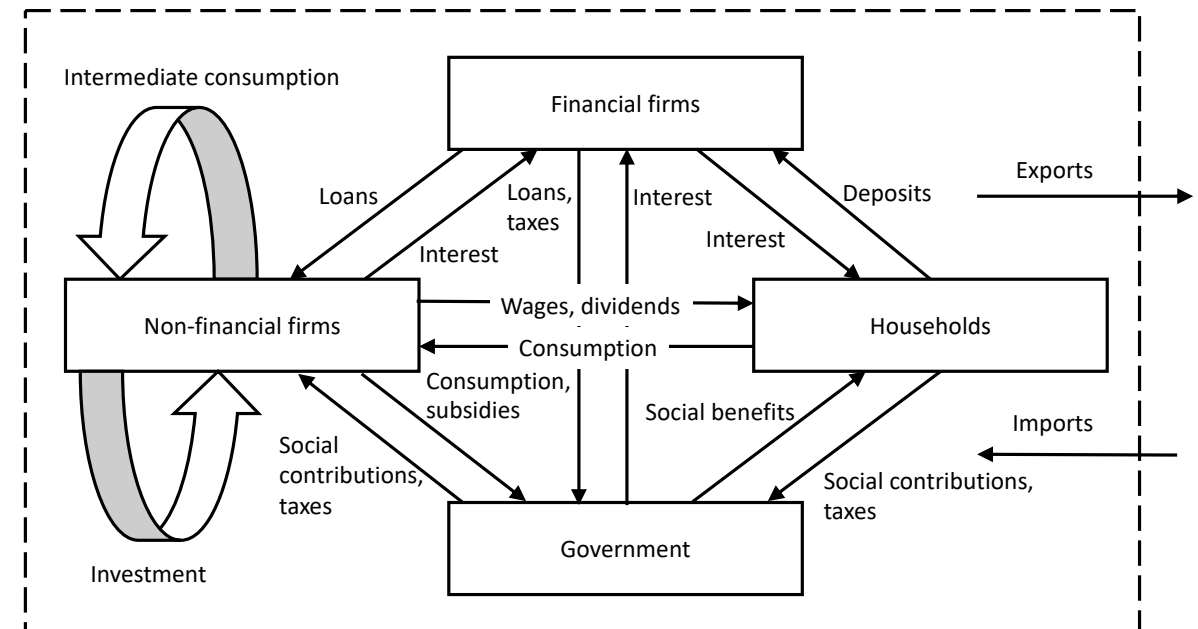
- Statistical models using (mostly linear) time series analysis offer good forecasting performance
 - large-scale macroeconomic models that use large amounts of data are possible...
 - ...but are weak in providing an explanation and interpretation of economic events
- DSGE and other models derived from economic theory
 - provide explanation and interpretation of economic events...
 - ...by depicting the micro-founded behaviour of agents
 - but for methodological reasons are restricted to smaller models with fewer variables than statistical models
- ABMs
 - **combine** advantages from large-scale **statistical models** and models derived from **economic theory**
 - can be **large-scale** and derived from economic theory at the same time
 - can compete with other models in **out-of-sample prediction** performance

IIASA macroeconomic ABM

Overview of the IIASA ABM

Agents:

- Non-financial corporations (**firm sector**), limited companies and self-employed
- Financial corporations (**banking sector**), one representative bank
- Individual persons (**household sector**)
 - Employed (active on labor market)
 - Unemployed (involuntarily idle)
 - Investor (own firms)
 - Inactive households (not active on labor market, receive social benefits)
- General **government** (consists of central, state and local governments)
- **Central Bank**



Major economic agents and their interactions

Mechanisms of the ABM

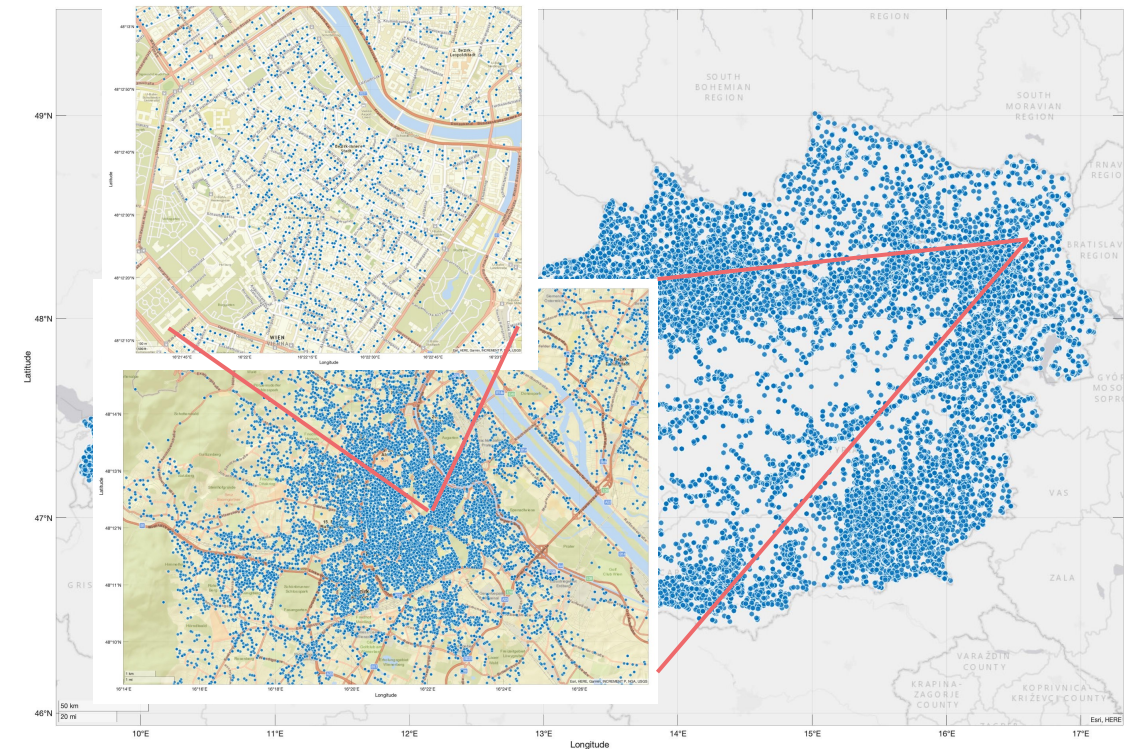
- Firms in 64 sectors (NACE) produce goods and services by using labor, capital and intermediate inputs from other firms
- *Bounded rationality*: Firms and consumers form expectations about future developments using adaptive learning and simple heuristics depending on the expected growth rate and inflation
- Consumption networks and supply chains are formed through *search-and-matching* processes:
 - Firms are randomly "*visited*" by consumers
 - The likelihood that firms are visited by consumers correlates negatively with the price and positively with firm size
 - Inventories and involuntary savings result from the search and matching process
- The labor market is also modeled with a search-and-matching process
- Demand for funding of firms is based on expectations of the expected future cash flow
- Banks grant loans based on financial conditions of firms and with respect to minimum capital requirements
- The general government acts a consumer (government consumption) and as a "redistributive entity"

Key modeling choices of the ABM

- Includes **all sectors** (financial, non-financial, households, a general government) populated with a large number of **heterogenous agents** calibrated to census and survey (LFS) data
- Includes a **complete GDP identity** with *all transactions* in products, non-financial assets, and distributive transactions calibrated to national accounting data
- Rational expectations are relaxed with **adaptive learning** (Hommes & Zhu, 2014)
- Includes a **multi-sector production network** calibrated to input-output tables
- Has **decentralized markets**, which allows for **trade frictions**
- Incorporates **financial frictions** with a **financial accelerator** and **debt-financed investment** (Bernanke, Gertler, & Gilchrist 1996)
- Allows **non-linear responses**, which may be underestimated by linearized DSGE models (Lindé, 2018), and for the possibility of **endogenous economic crises without exogenous shocks**
- The ABM is **validated** based on the comparison of its **forecast performance** (out-of-sample prediction) with that of econometric and DSGE models

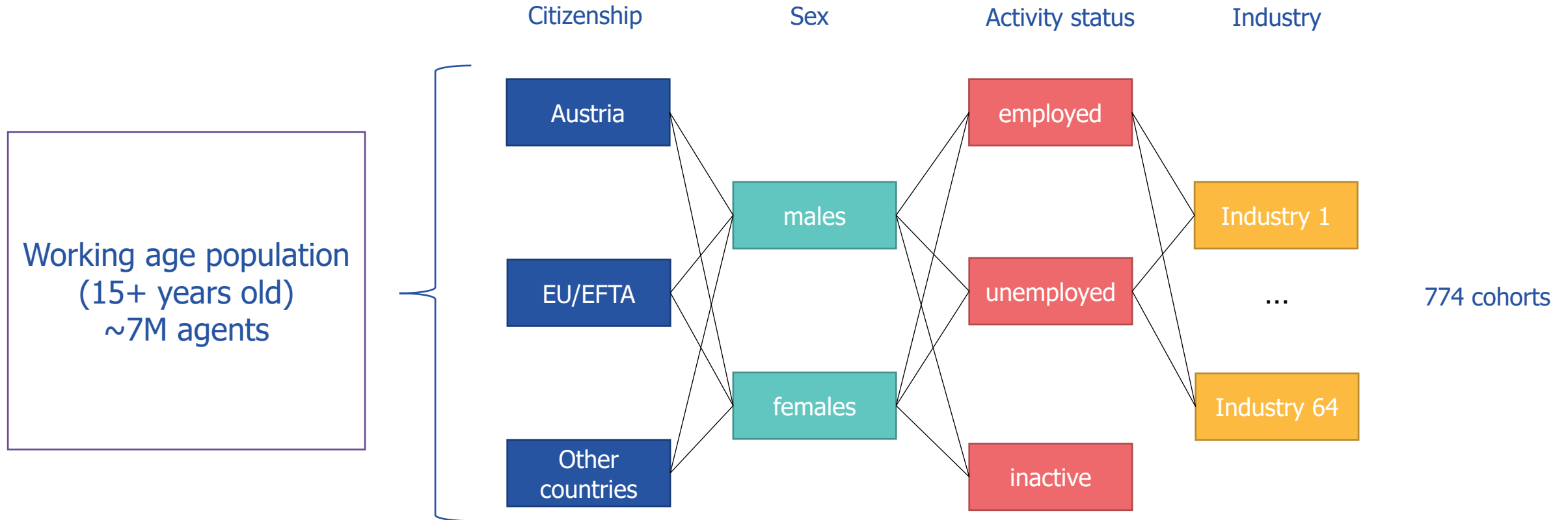
Calibration of the ABM for Austria

Data type	Data purpose
Census and business demography	Populate the model with realistic numbers of agents-individuals and agents-firms
Input-output <i>industry × industry</i> tables (IOTs); all economic activities as classified by the European System of Accounts: 64 industries (NACE-level 2)	Describe the sale and purchase relationships between producers and consumers within an economy, i.e., flows of final and intermediate goods and services
Government statistics and sector accounts	Calibrate tax rates, social insurance rates, etc.
National accounts (GDP and main components) and money market interest rates	Estimate exogenous processes and the Taylor rule to determine the policy rate
Statutory guidelines, financial regulation, and banking practices	Determine capital requirements, inflation targets, unemployment benefit replacement rate, etc.



611278 firms

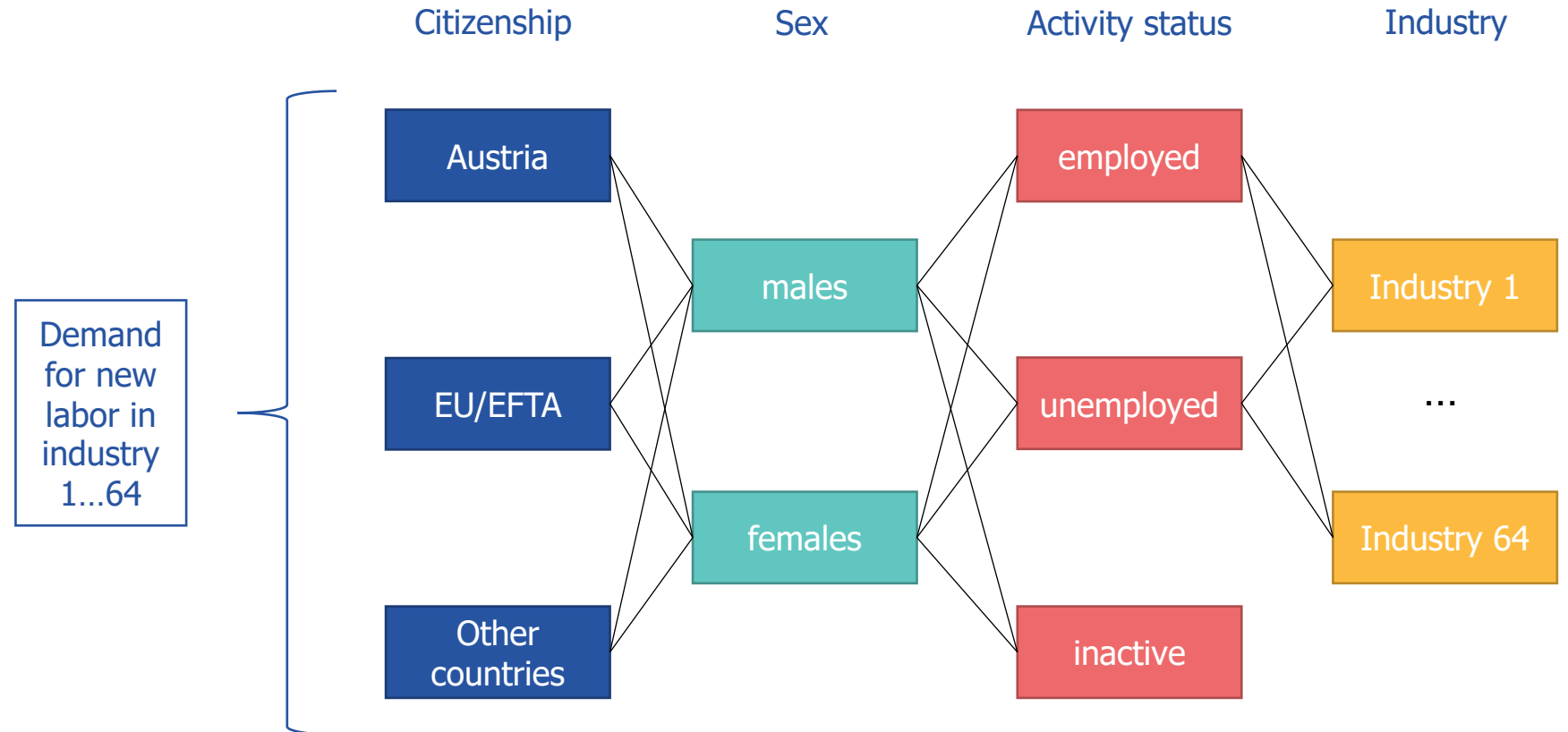
Calibration of the population module of the ABM



Data source: Statistics Austria

Calibration of labour market transitions

Labor market transitions to employment are guided by transition probabilities which are estimated from absolute values: flows of individuals between the activity states (employed, unemployed, inactive) divided by stocks of individuals in each activity state.

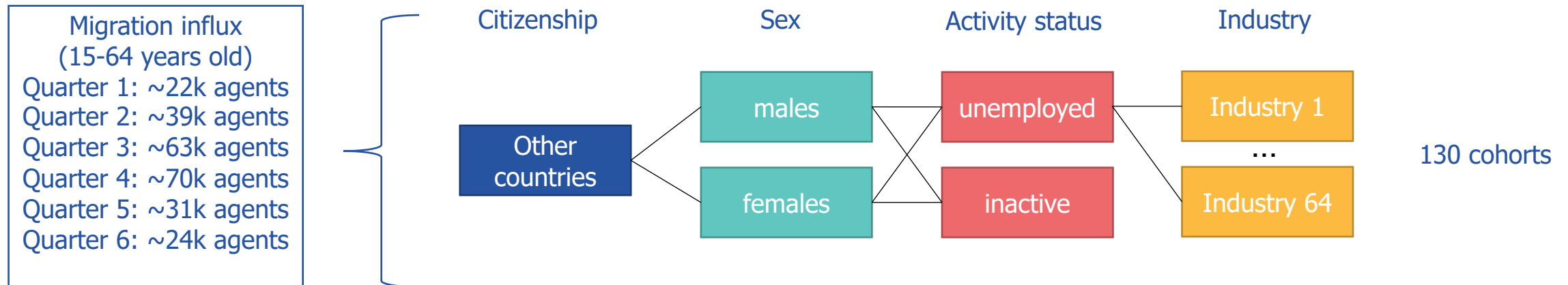


Data source: Statistics Austria, Register-based Labour Market Career (ERV) data
Data on the employment history of each person in Austria from 2009 onwards (~4.1 mln. employees; ~20 mln. employment relationships)

Calibration of the migration scenario

Migration scenario: 250,000 additional agents-migrants of working age (15-64 years old) are dynamically added to the ABM every quarter for six quarters.

The numbers of agents-migrants with certain attributes (citizenship, sex, activity status and industry) are calibrated to resemble the composition of the 2015 refugee crisis in Austria.



Data sources: JRC migration scenarios, Statistics Austria, UNHCR, Online-Arbeitsmarktinformationssystem

ABM implementation

Two implementations of the IIASA Macroeconomic ABM exist:

- The “reference” implementation is written in MATLAB. In the spirit of Dynare, the model is implemented almost as it is described in the manuscript. This implementation is available on <https://github.com/iiasa/abm> and on [zenodo](#).
- A Distributed Memory Parallel (DMP-HPC) implementation was developed in Gill et al. (2021).



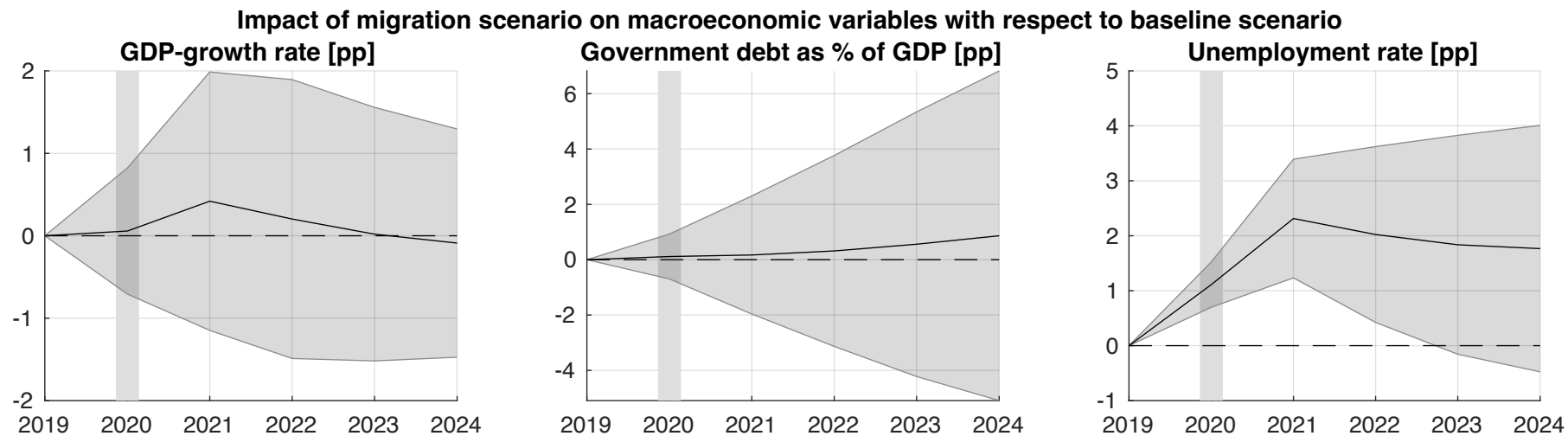
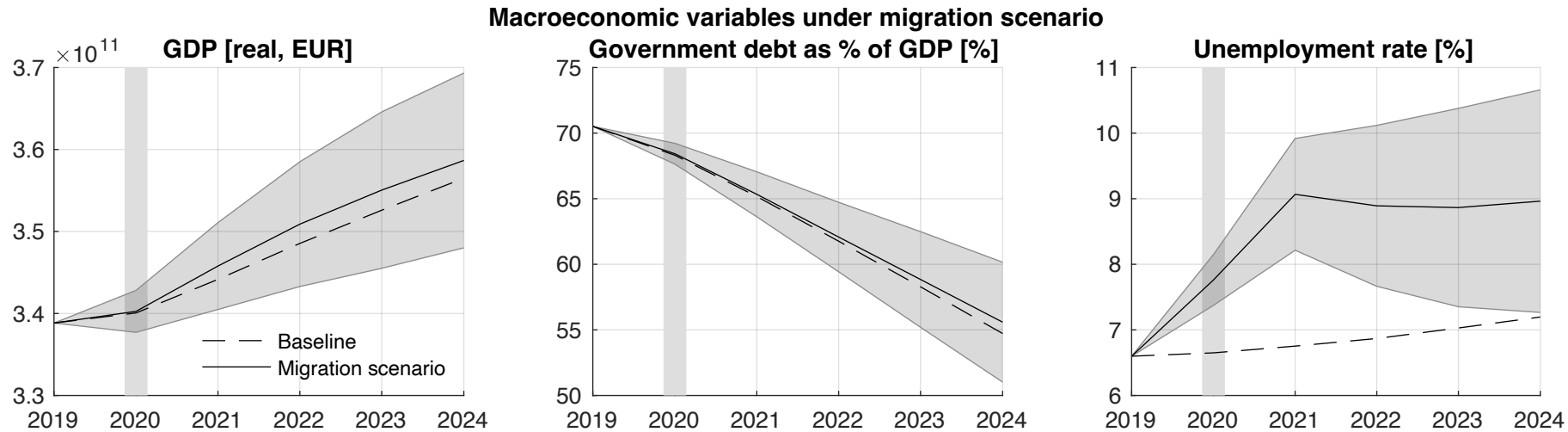
Baseline model
code and data at
Zenodo



Model paper
published in
European
Economic Review

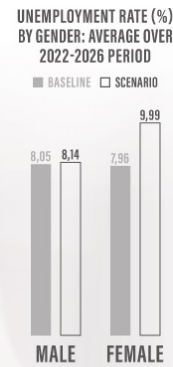
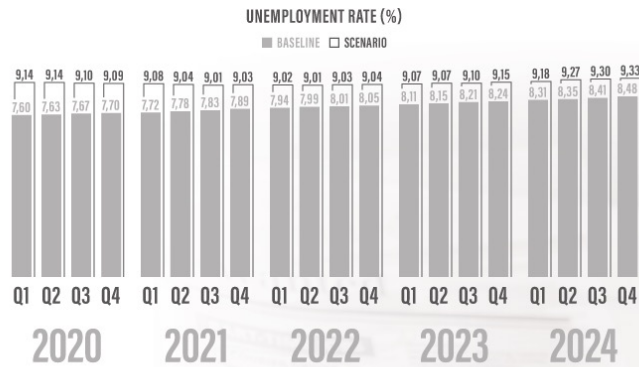
Simulation results

Macroeconomic impacts under the migration scenario

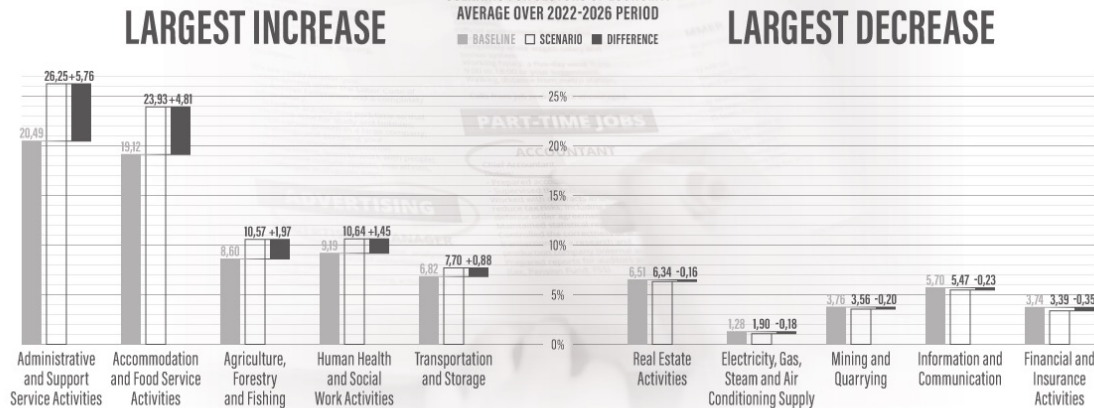


Labour market dynamics under the migration scenario

UNEMPLOYMENT DATA



DIFFERENCES IN UNEMPLOYMENT RATES (%) BETWEEN BASELINE AND MIGRATION SCENARIO FOR SECTORS OF ECONOMY: AVERAGE OVER 2022-2026 PERIOD



Nationality	Gender	Variable	0	1	2	3	4	5
NATIVES	MEN	u.r. (%)	5.20%	5.33%	5.59%	5.83%	6.10%	6.35%
		Δ u.r. (p.p)	+0.00%	+0.03%	+0.10%	+0.25%	+0.46%	+0.71%
		# U (units)	85350	87833	92680	97509	102824	107966
	WOMEN	u.r. (%)	5.21%	5.39%	5.73%	6.06%	6.37%	6.64%
		Δ u.r. (p.p)	+0.00%	+0.01%	+0.03%	+0.13%	+0.31%	+0.54%
		# U (units)	80615	83663	89854	95893	101781	107241
EU	MEN	u.r. (%)	7.07%	6.80%	6.28%	5.92%	5.78%	5.77%
		Δ u.r. (p.p)	+0.00%	+0.09%	+0.30%	+0.52%	+0.74%	+0.96%
		# U (units)	14483	14219	13731	13504	13647	14028
	WOMEN	u.r. (%)	8.91%	8.91%	8.89%	8.87%	8.92%	9.01%
		Δ u.r. (p.p)	+0.00%	+0.04%	+0.14%	+0.34%	+0.59%	+0.87%
		# U (units)	18211	18404	18845	19343	19996	20739
Other Countries	MEN	u.r. (%)	11.80%	11.51%	10.86%	10.23%	9.73%	9.36%
		Δ u.r. (p.p)	+0.00%	+0.09%	+0.34%	+0.67%	+1.02%	+1.36%
		# U (units)	28023	27450	26161	24912	23975	23309
	WOMEN	u.r. (%)	14.34%	14.41%	14.53%	14.65%	14.80%	14.96%
		Δ u.r. (p.p)	+0.00%	+0.03%	+0.10%	+0.24%	+0.45%	+0.73%
		# U (units)	30149	30378	30865	31383	32003	32657
Refugees	MEN	u.r. (%)	28.86%	25.29%	18.76%	13.81%	10.57%	8.42%
		Δ u.r. (p.p)	+0.00%	+35.66%	+45.87%	+38.82%	+31.86%	+26.04%
		# U (units)	11319	10162	7955	6199	5003	4183
	WOMEN	u.r. (%)	32.47%	21.00%	9.14%	4.61%	2.89%	2.18%
		Δ u.r. (p.p)	+0.00%	+33.20%	+33.17%	+19.66%	+11.62%	+7.19%
		# U (units)	1795	1298	700	430	318	275
Δ # U (units)			+0	+7290	+12977	+8401	+5493	+3823

u.r.: Unemployment rate in the baseline scenario; Δ u.r.: Difference in the unemployment rate (in p.p.) between the migration scenario and the baseline scenario; #U: Absolute number of unemployed persons in the baseline scenario; Δ#U: Difference in the absolute number of unemployed persons between the migration scenario and the baseline scenario

Sectoral labour market dynamics under the migration scenario

Industry	Variable	0	1	2	3	4	5
A	u.r. (%)	8.19%	8.08%	8.26%	8.67%	9.21%	9.71%
	Δ u.r. (p.p)	+0.00%	+2.38%	+5.07%	+4.73%	+4.53%	+4.55%
	# U (units)	1791	1770	1831	1955	2112	2265
	Δ # U (units)	+0	+583	+1311	+1252	+1229	+1256
B	u.r. (%)	2.75%	2.76%	2.73%	2.83%	3.01%	3.12%
	Δ u.r. (p.p)	+0.00%	+0.02%	+0.10%	+0.18%	+0.29%	+0.43%
	# U (units)	167	172	179	191	206	216
	Δ # U (units)	+0	+2	+7	+13	+20	+31
C	u.r. (%)	3.40%	3.53%	3.71%	3.94%	4.24%	4.51%
	Δ u.r. (p.p)	+0.00%	+0.36%	+0.78%	+0.75%	+0.80%	+0.89%
	# U (units)	21669	22715	24448	26522	29033	31414
	Δ # U (units)	+0	+2442	+5431	+5421	+5917	+6663
D	u.r. (%)	1.40%	1.12%	0.81%	0.72%	0.70%	0.69%
	Δ u.r. (p.p)	+0.00%	+0.05%	+0.06%	+0.03%	+0.10%	+0.20%
	# U (units)	73	59	42	38	37	37
	Δ # U (units)	+0	+2	+3	+2	+6	+11
E	u.r. (%)	4.05%	4.20%	4.94%	5.86%	6.83%	7.79%
	Δ u.r. (p.p)	+0.00%	+0.61%	+1.13%	+0.80%	+0.83%	+1.08%
	# U (units)	637	663	790	958	1142	1331
	Δ # U (units)	+0	+101	+196	+146	+158	+210
F	u.r. (%)	5.17%	5.11%	4.98%	4.92%	4.97%	5.07%
	Δ u.r. (p.p)	+0.00%	+0.57%	+1.01%	+0.65%	+0.49%	+0.52%
	# U (units)	14768	14626	14371	14372	14676	15134
	Δ # U (units)	+0	+1738	+3176	+2127	+1658	+1789
G	u.r. (%)	6.54%	6.59%	6.71%	6.86%	7.05%	7.26%
	Δ u.r. (p.p)	+0.00%	+0.61%	+1.08%	+0.82%	+0.74%	+0.78%
	# U (units)	41306	41795	43050	44528	46361	48307
	Δ # U (units)	+0	+4198	+7853	+6272	+5808	+6125
H	u.r. (%)	6.07%	5.97%	5.71%	5.52%	5.50%	5.51%
	Δ u.r. (p.p)	+0.00%	+0.81%	+1.63%	+1.40%	+1.28%	+1.32%
	# U (units)	11780	11625	11230	11008	11119	11262
	Δ # U (units)	+0	+1695	+3505	+3060	+2850	+2944
I	u.r. (%)	18.31%	17.92%	17.04%	16.05%	15.12%	14.25%
	Δ u.r. (p.p)	+0.00%	+4.27%	+8.82%	+8.03%	+7.18%	+6.49%
	# U (units)	46739	45712	43345	40775	38376	36155
	Δ # U (units)	+0	+14089	+30914	+27608	+24183	+21409
K	u.r. (%)	3.88%	3.95%	4.29%	4.71%	5.19%	5.66%
	Δ u.r. (p.p)	+0.00%	+0.13%	+0.20%	+0.13%	+0.29%	+0.55%
	# U (units)	4324	4422	4854	5429	6080	6741
	Δ # U (units)	+0	+156	+251	+194	+403	+736

Industry	Variable	0	1	2	3	4	5
J	u.r. (%)	2.63%	2.83%	3.18%	3.51%	3.87%	4.19%
	Δ u.r. (p.p)	+0.00%	+0.01%	+0.15%	+0.24%	+0.19%	+0.03%
	# U (units)	3087	3348	3815	4285	4795	5264
	Δ # U (units)	+0	+13	+169	+274	+207	+0
L	u.r. (%)	5.96%	5.78%	5.43%	5.13%	4.93%	4.78%
	Δ u.r. (p.p)	+0.00%	+0.25%	+0.23%	+0.08%	+0.11%	+0.24%
	# U (units)	2915	2830	2670	2535	2450	2391
	Δ # U (units)	+0	+132	+144	+69	+87	+155
M	u.r. (%)	4.62%	4.54%	4.54%	4.66%	4.91%	5.20%
	Δ u.r. (p.p)	+0.00%	+0.24%	+0.41%	+0.34%	+0.46%	+0.70%
	# U (units)	9586	9436	9525	9901	10559	11339
	Δ # U (units)	+0	+531	+942	+807	+1104	+1688
N	u.r. (%)	19.02%	18.41%	17.09%	15.85%	14.86%	14.09%
	Δ u.r. (p.p)	+0.00%	+4.91%	+10.13%	+9.11%	+8.05%	+7.22%
	# U (units)	52442	50577	46711	43221	40538	38516
	Δ # U (units)	+0	+17621	+38362	+33602	+28993	+25517
O	u.r. (%)	2.42%	3.07%	4.41%	5.62%	6.67%	7.62%
	Δ u.r. (p.p)	+0.00%	+0.08%	+0.26%	+0.33%	+0.45%	+0.59%
	# U (units)	16096	20652	30195	39264	47477	55139
	Δ # U (units)	+0	+587	+1887	+2426	+3432	+4581
P	u.r. (%)	4.45%	4.56%	4.73%	4.82%	4.83%	4.81%
	Δ u.r. (p.p)	+0.00%	+0.35%	+0.72%	+0.73%	+0.82%	+0.95%
	# U (units)	7781	8013	8399	8626	8718	8748
	Δ # U (units)	+0	+646	+1374	+1413	+1588	+1842
Q	u.r. (%)	8.05%	8.15%	8.32%	8.46%	8.57%	8.64%
	Δ u.r. (p.p)	+0.00%	+1.28%	+2.78%	+2.63%	+2.46%	+2.39%
	# U (units)	23866	24274	25051	25699	26283	26748
	Δ # U (units)	+0	+4250	+9562	+9149	+8675	+8460
R	u.r. (%)	9.72%	9.20%	8.13%	7.14%	6.34%	5.72%
	Δ u.r. (p.p)	+0.00%	+0.55%	+1.00%	+0.90%	+0.93%	+1.04%
	# U (units)	3877	3661	3224	2824	2511	2268
	Δ # U (units)	+0	+248	+463	+417	+425	+465
S	u.r. (%)	7.01%	7.00%	6.96%	6.88%	6.84%	6.83%
	Δ u.r. (p.p)	+0.00%	+0.94%	+1.84%	+1.56%	+1.40%	+1.34%
	# U (units)	7041	7056	7063	7044	7073	7123
	Δ # U (units)	+0	+1038	+2110	+1827	+1657	+1601
TOTAL	u.r. (%)	6.60%	6.65%	6.75%	6.86%	7.02%	7.19%
	Δ u.r. (p.p)	+0.00%	+1.12%	+2.31%	+2.02%	+1.83%	+1.76%
	# U (units)	269945	273406	280793	289173	299546	310399
	Δ # U (units)	+0	+50046	+107322	+95533	+87986	+85482

	Industry
A	Agriculture, Forestry and Fishing
B	Mining and Quarrying
C	Manufacturing
D	Electricity, Gas, Steam and Air Conditioning Supply
E	Water Supply; Sewerage, Waste Management and Remediation Activities
F	Construction
G	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles
H	Transportation and Storage
I	Accommodation and Food Service Activities
J	Information and Communication
K	Financial and Insurance Activities
L	Real Estate Activities
M	Professional, Scientific and Technical Activities
N	Administrative and Support Service Activities
O	Public Administration and Defence; Compulsory Social Security
P	Education
Q	Human Health and Social Work Activities
R	Arts, Entertainment and Recreation
S	Other Service Activities
T	Activities of Households as Employers; Undifferentiated Goods and Services Producing Activities of Households for Own Use
U	Activities of Extraterritorial Organisations and Bodies

References & further reading

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