Refugee Inflows and Regional Adjustment in an Ageing Economy: A Dynamic Spatial General Equilibrium Analysis

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Abstract

This paper studies how labor-supply shocks interact with regional demographic heterogeneity in ageing economies. I employ a dynamic multi-regional general equilibrium model with age cohorts, forward-looking migration, trade linkages, and endogenous capital accumulation. Embedding region-specific demographics and labor market conditions, the model allows a national labor-supply shock to generate heterogeneous regional and intergenerational outcomes. Calibrated to German federal states and applied to the 2015 refugee inflow, the analysis shows modest aggregate GDP gains but substantial regional variation. GDP and capital stocks rise everywhere, while employment effects differ due to internal migration: some regions gain workers, others lose them. Transitional dynamics and initial wealth shape output and welfare outcomes. Younger and middle-aged workers face small welfare losses, while capital owners benefit from higher returns, generating a modest redistribution from labor to capital. Older regions experience smaller worker welfare losses but also weaker capital gains. Overall, migration reinforces agglomeration and capital deepening, supporting aggregate growth, yet adjustment dynamics produce heterogeneous regional and intergenerational effects.

Keywords:Labor supply shocks, Regional heterogeneity, Demographic change.

JEL Classification: J11, R13, R23.

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1 Introduction

Demographic change has become a defining feature of many advanced economies, with ageing populations, declining fertility, and persistent regional disparities in migration shaping the evolution of local labor markets. In Germany, these trends are particularly pronounced across regions: while some metropolitan areas continue to attract younger and more educated workers, several eastern and peripheral regions face shrinking and ageing populations. Such heterogeneity raises important questions about how exogenous labor supply shocks interact with pre-existing demographic structures and regional factor endowments. Understanding these interactions is crucial for assessing both aggregate and distributional effects of migration.

The inflow of Syrian refugees to Germany in 2015 triggered an intense political debate. After an initially welcoming stance toward incoming refugees, Germany reintroduced border controls and temporarily suspended parts of the Schengen arrangement. In the aftermath of the so-called "refugee crisis", support for right-wing populist and extremist parties increased (Niemann and Blöser, 2021). A decade later, the long-term consequences of this migration wave remain politically salient, including recurring public debates about whether Syrians who arrived in 2015 should return to their country of origin.

Beyond its political relevance, the 2015 refugee inflow offers an informative setting for economic analysis. Germany exhibits substantial regional heterogeneity in GDP per capita, demographic structures, and labor market conditions. Studying this migration episode through the lens of demographic change and regional inequality can therefore shed light on how large and sudden migration waves interact with pre-existing structural differences. The arrival of more than 125,000 working-age first-time asylum applicants from Syria within 2015[1] constituted a sizeable labor supply shock, driven primarily by geopolitical events rather than domestic economic conditions. At the same time, refugees were allocated across regions according to administrative distribution rules, generating cross-regional variation in exposure to the shock. Importantly, this inflow occurred against the backdrop of pronounced demographic divergence between German regions. The 2015 refugee wave thus provides a natural setting to examine how an aggregate shock interacts with heterogeneous regional age structures, labor market tightness, and capital endowments, and whether migration can mitigate local demographic decline or instead amplify spatial disparities.

The direction of these effects is theoretically ambiguous. On the one hand, the arrival of predominantly young refugees may alleviate demographic pressures in ageing regions and counteract local labor shortages, thereby dampening existing growth disparities. On the other hand, if refugees disproportionately settle in economically stronger or more urban regions, migration may reinforce agglomeration forces and amplify pre-existing regional inequalities (e.g. Fujita et al. (1999) or Redding and Rossi-Hansberg (2017)). Moreover, internal migration patterns

[1] Source: Eurostat, Asylum statistics: first-time applicants, 2015.

and urban transitions are known to differ substantially across regions, which can further condition how such inflows translate into local economic outcomes (Randolph and Storper, 2023). Whether refugee inflows mitigate or exacerbate spatial divergence therefore remains an empirical and quantitative question.

A large body of literature examines the labor market effects of immigration and labor supply shocks, typically focusing on national-level outcomes or average wage and employment effects within static labor demand or partial equilibrium frameworks (e.g., Borjas (2003) or Card (2001)). More recent contributions incorporate general equilibrium adjustments. Iftikhar and Zaharieva (2019) analyze the increase in immigration to Germany between 2012 and 2016 and find moderate negative effects on low-skilled workers, while other groups benefit. Although their framework allows for sectoral reallocation, it does not incorporate endogenous capital accumulation, spatial heterogeneity, or migration dynamics. Busch et al. (2020) evaluate the macroeconomic effects of refugee inflows to Germany between 2015 and 2018 using an overlapping-generations model. They show that low-skilled natives experience welfare losses that can, in aggregate, be offset by gains accruing to high-skilled natives. However, the model assumes a closed economy in steady state and abstracts from regional differentiation. Caliendo et al. (2023) study the impact of Ukrainian refugees on the long-run welfare of European regions, incorporating dynamic capital adjustment and forward-looking migration decisions. Yet, their framework does not explicitly account for within-country regional heterogeneity.

A related strand of literature uses dynamic spatial equilibrium models to study regional adjustment and migration. Desmet et al. (2018) construct a high-resolution dynamic spatial growth model to analyze how migration frictions shape the geographic distribution of economic activity. While their framework provides a strong treatment of geography and spatial development, it does not consider discrete migration shocks or detailed labor market mechanisms. More recently, Bilal and Rossi-Hansberg (2023) examine the long-run costs of climate change across U.S. counties in a model with forward-looking migration decisions and rich spatial dynamics. Although their approach allows for endogenous regional population movements and capital adjustment, it does not focus on refugee-driven labor supply shocks nor does it explicitly incorporate demographic heterogeneity or detailed labor market structures.

Overall, much of the existing literature abstracts from subnational demographic variation and treats the receiving economy as largely homogeneous. Consequently, limited attention has been paid to how regional differences in age structure, labor market tightness, and capital intensity shape the local effects of labor supply shocks.

This paper contributes to the literature by integrating a large labor supply shock into a multi-regional dynamic general equilibrium framework that explicitly incorporates demographic heterogeneity, endogenous capital adjustment, and regional labor market structures. By jointly modeling demographic structure, endogenous capital accumulation, and regional labor market adjustment within a unified framework, the analysis allows regional age structures, employment

compositions, and migration patterns to shape local dynamics. This unified framework makes it possible to assess how the same aggregate shock can generate markedly different regional outcomes and distributional effects, even when national averages appear modest.

The analysis has direct policy relevance in the context of ageing societies facing uneven regional development. As demographic divergence persists and migration continues to reshape local labor markets, evaluating labor supply shocks solely through national aggregates may lead to misleading conclusions about welfare and distributional effects. By quantifying region-specific adjustment paths, the paper provides a more granular basis for assessing the long-run consequences of migration in ageing economies.

2 Model

This paper builds on the dynamic spatial general equilibrium framework developed in Caliendo et al. (2019) and extends it along the lines of Caliendo et al. (2023) to incorporate heterogeneous skills, migration with frictions, labor-supply shocks, international trade, and endogenous capital accumulation as in Kleinman et al. (2023). The world economy consists of N regions that trade differentiated goods subject to iceberg trade costs. Production uses high-skilled labor, low-skilled labor, and region-specific capital structures. Labor is internationally mobile subject to migration costs and idiosyncratic location preferences, while capital structures are immobile and accumulated locally by forward-looking capitalists. The model delivers full transitional dynamics and is solved using dynamic-hat algebra.

2.1 Production and Trade

In each region i at time t, a continuum of firms produces differentiated varieties under perfect competition. Productivity draws follow a Fréchet distribution with dispersion parameter θ, generating an Eaton–Kortum structure of trade (Eaton and Kortum, 2002). Output is produced using a CES aggregator of high- and low-skilled effective labor combined with local capital structures in Cobb–Douglas form. Let T_{it} denote region-specific productivity, $a_{is,t}$ skill-intensity parameters, ρ the elasticity of substitution between skill types s, with h as high skill and l as low skill. L denotes labor and γ_i is the capital share. Unit costs depend on skill-specific wages $w_{is,t}$ and the rental rate of capital r_{it}:

$$Y_{it} = T_{it}\left[\left(\sum_{s\in\{h,l\}} a_{is,t}^{\frac{1}{\rho}} L_{is,t}^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}}\right]^{1-\gamma_i} K_{it}^{\gamma_i}. \tag{1}$$

Given iceberg trade costs from region j to i, $\kappa_{ij,t} \geq 1$, bilateral trade shares and price indices follow the standard Eaton–Kortum gravity structure and depend on relative unit costs u, trade costs, and technology parameters T:

$$\pi_{ij,t} = \frac{T_{j,t} \left(u_{j,t}\, \kappa_{ij,t}\right)^{-\theta}}{\sum_k T_{k,t} \left(u_{k,t}\, \kappa_{ik,t}\right)^{-\theta}}. \tag{2}$$

Conditional on wages and rental rates, production decisions are static within each period. Production costs depend on labor costs by skill $w_{is,t}$, the rental rate of capital $r_{i,t}$, and a region-specific constant ξ_i:

$$u_{i,t} = \xi_i \left(\sum_{s \in \{h,l\}} a_{is,t} w_{is,t}^{1-\rho} \right)^{\frac{1-\gamma_i}{1-\rho}} r_{i,t}^{\gamma_i}. \tag{3}$$

The local price index is given by:

$$P_{i,t} = \left(\sum_{j=1}^{N} T_{j,t} \left(\kappa_{ij,t} u_{j,t} \right)^{-\theta} \right)^{-1/\theta}. \tag{4}$$

2.2 Households and Migration

Households are heterogeneous by age group $a \in \{y, o\}$, nationality n, and employment status $\ell \in \{e, ne\}$, with e denoting employment, and ne is non-employment. In each period, households choose a region of residence and employment status, taking into account wages, prices, migration costs, and future utility. Migration is subject to bilateral, status-dependent costs and idiosyncratic Type-I extreme value preference shocks with dispersion parameter ν, which generate a multinomial logit structure for gross migration flows.

Instantaneous utility depends on real income: employed workers consume wage income, while non-employed individuals receive home production. Households are forward-looking and discount the future at rate β. C denotes the consumption aggregator. The value function incorporates expected continuation values of a person with nationality n across all possible destinations and employment states, net of migration costs $\tau_{ij}^{a,\ell o}$ by age group a between region i to j and employment status ℓ to o.

$$V_{i,t}^{n,a,\ell} = \log C_{i,t}^{a,\ell} + \nu \log \left(\sum_{j=1}^{N} \sum_{o \in \{e,ne\}} \exp \left(\frac{\beta V_{j,t+1}^{n,a,o} - \tau_{ij,t}^{n,a,\ell o}}{\nu} \right) \right). \tag{5}$$

This structure delivers closed-form expressions for bilateral migration shares as functions of expected future utilities and migration frictions:

$$\mu_{ij,t}^{n,a,\ell o} = \frac{\exp\left(\beta V_{j,t+1}^{n,a,o} - \tau_{ij,t}^{n,a,\ell o}\right)^{1/\nu}}{\sum_{k=1}^{N}\sum_{q\in\{e,ne\}}\exp\left(\beta V_{k,t+1}^{n,a,q} - \tau_{ik,t}^{n,a,\ell q}\right)^{1/\nu}}. \tag{6}$$

The law of motion for the population distribution follows from aggregating individual migration probabilities. Next period's population in each country, age group, and employment state equals the sum of migrants arriving from all origins, weighted by origin populations and bilateral migration shares.

2.3 Capital Accumulation

Capital structures are region-specific and immobile. They are owned by local capitalists who choose consumption and investment to maximize discounted utility. Capital income equals the rental rate times the existing stock, and the law of motion features standard depreciation at rate δ. Optimal investment decisions imply a linear transition equation linking next period's capital stock to the current real rental rate. Because capital adjusts gradually, it becomes a key state variable driving transitional dynamics.

$$K_{i,t+1} = \beta\left[(1-\delta) + \frac{r_{i,t}}{P_{it}}\right]K_{it} \tag{7}$$

2.4 Market Clearing and Income

Labor markets clear in each country and age group: wages equal the marginal revenue product of effective labor implied by the trade structure and production technology. Capital markets clear locally, with the entire stock rented to firms. Goods markets clear according to the Eaton–Kortum structure described above, which implies gravity trade shares as functions of relative unit costs and trade costs. Total income I equals the sum of labor income across age groups and capital income, where $L_{ia,t}^{e}$ denotes employed workers of age group a in region i and r_{it} is the region-specific rental rate of capital:

$$I_{it} = \sum_{s} w_{ia,t} L_{ia,t}^{e} + r_{it} K_{it}.$$

2.5 Equilibrium and Transitional Dynamics

A sequential competitive equilibrium consists of wages, rental rates, price indices, migration flows, population allocations, value functions, and capital stocks such that households and capitalists optimize, firms behave competitively, migration flows are consistent with value functions, and all markets clear.

Following Caliendo et al. (2019), the model is solved using dynamic-hat algebra. All equilibrium conditions are expressed in proportional changes relative to an initial allocation. This approach avoids the need to identify levels of fundamental productivity and allows computation of the full transition path even when the initial economy is not in steady state. It is particularly well suited to analyzing unanticipated shocks.

2.6 Labor-Supply Shock in the Counterfactual Scenario

I study the effects of an unanticipated, one-time labor-supply shock that increases the stock of households in period $t = 1$. The shock differs across age groups, employment status, and nationality. After the initial impact, newly arrived households face the same migration costs and make location choices under the same decision rules as incumbent households.

Because capital structures adjust gradually while labor reallocates immediately across space, the shock generates rich transitional dynamics. In the short run, the increase in labor relative to capital raises the labor-to-capital ratio, putting downward pressure on real wages and increasing the rental rate of capital. Over time, forward-looking capitalists increase investment, expanding the capital stock and amplifying long-run output responses. The interaction between migration, trade, and endogenous capital accumulation determines aggregate and distributional effects between regions, employment-age groups, and capital owners.

3 Data

3.1 Syrian refugee data

Detailed data on the regional distribution of refugees by age group and employment status are not publicly available. I therefore combine country-level asylum statistics with regional information from EU-LFS microdata to construct regional estimates for 2015.

At the country level, I use Eurostat data on first-time asylum applications of Syrian citizens aged 15–64 in 2015, which capture the inflow of new applicants during that year. In absolute terms, Germany received the highest number of first-time Syrian asylum applicants among European countries.

To estimate the regional (NUTS-1) distribution of working-age Syrian refugees by age group (young/old) and employment status (employed/unemployed), I apply a two-step Multilevel Regression with Poststratification (MRP) procedure.

Using individual EU-LFS microdata for 2015, I estimate the within-region distribution of four age–employment categories with a hierarchical multinomial logistic regression. The category "old-aged, employed" serves as the reference category.

For each region r and non-reference category k, the log-odds relative to the reference category are specified as:

$$\log \frac{P_{r,k}}{P_{r,\text{ref}}} = \alpha_k + X_r \beta_k + u_{r,k}, \quad u_{r,k} \sim \mathcal{N}(0, \sigma_k^2), \tag{8}$$

where X_r includes region-specific GDP per capita and the tertiary-education share. The terms $u_{r,k}$ are region-level random intercepts allowing baseline log-odds to vary across regions.

Weakly informative priors are imposed to stabilize estimation in data-sparse regions:

- $\beta_k \sim \mathcal{N}(0, 0.5)$ for slope coefficients,
- $\alpha_k \sim \mathcal{N}(0, 1)$ for intercepts,
- $\sigma_k \sim$ Student-$t(3, 0, 2.5)$ for region-level standard deviations.

For each posterior draw $s \in \{1, \ldots, 4000\}$, the linear predictor is:

$$\eta_{r,k}^{(s)} = \log \frac{P_{r,k}}{P_{r,\text{ref}}} = \alpha_k^{(s)} + X_r \beta_k^{(s)} + u_{r,k}^{(s)}. \tag{9}$$

Category probabilities are obtained via the multinomial logit transformation:

$$p_{r,k}^{(s)} = \frac{\exp\left(\eta_{r,k}^{(s)}\right)}{1 + \sum_{j \neq \text{ref}} \exp\left(\eta_{r,j}^{(s)}\right)}, \tag{10}$$

$$p_{r,\text{ref}}^{(s)} = \frac{1}{1 + \sum_{j \neq \text{ref}} \exp\left(\eta_{r,j}^{(s)}\right)}. \tag{11}$$

Convergence diagnostics (all $\hat{R} \approx 1$ and large effective sample sizes) and posterior predictive checks indicate satisfactory model fit. A full summary of the model parameters, including intercepts, slope coefficients, and region-level standard deviations, is provided in Table 3 in the Appendix.

In the second step, predicted regional probabilities are scaled to observed country-level asylum totals. At the time of the 2015 refugee inflow, the initial allocation of asylum seekers across German federal states was governed by the *Königsteiner Schlüssel*, an administrative quota system that distributes asylum applicants across states according to a weighted formula based on tax revenues and population size. This mechanism implies that economically larger and more populous states receive a proportionally larger share of asylum seekers.

Because detailed information on the exact state-level assignment of Syrian refugees by age and employment status is not publicly available, I approximate the regional allocation by distributing national asylum totals proportionally to regional population shares before applying the MRP-based age–employment composition. This approach closely mirrors the population component of the Königsteiner Schlüssel and captures the broad scaling of inflows across states, while allowing the age–employment composition to differ across regions according to the estimated MRP structure. The subsequent model dynamics then determine internal migration responses beyond the initial administrative allocation.

Here, A_c denotes the total number of first-time Syrian asylum applicants on the national level for year 2015 and retrieved from Eurostat. These totals are allocated to NUTS-1 regions in proportion to regional population shares $w_{r|c}$.

For each posterior draw s, the allocated count in region r and category k is:

$$\text{alloc}_{r,k}^{(s)} = p_{r,k}^{(s)} \times (A_c \cdot w_{r|c}). \tag{12}$$

Posterior means and 95% credible intervals are computed across draws. Regions with few or no Syrian observations in the LFS borrow strength from the hierarchical structure, implying shrinkage toward the covariate-predicted mean.

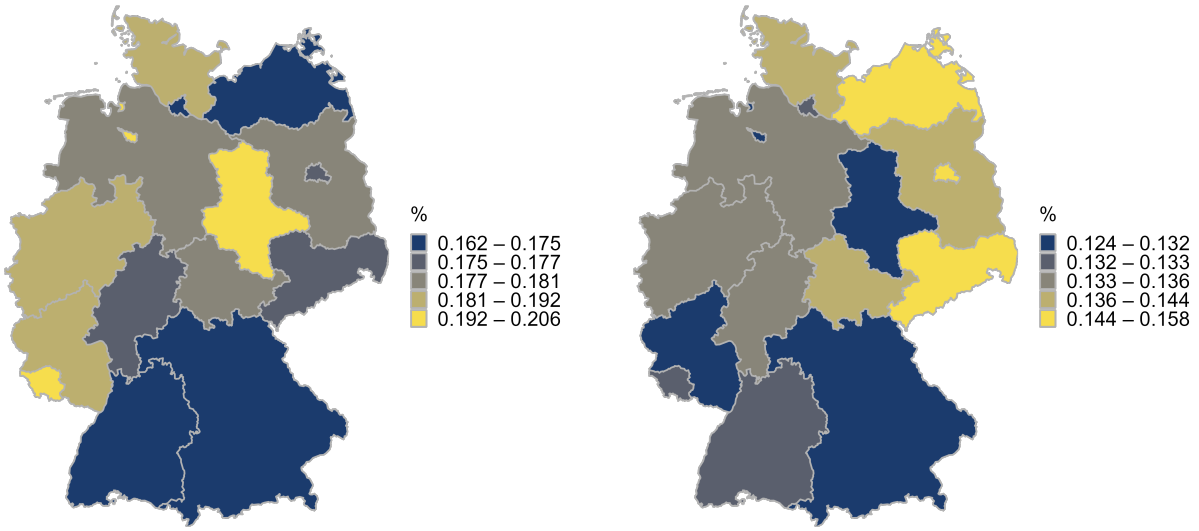
The resulting dataset contains, for each NUTS-1 region, posterior mean counts of Syrian refugees in four age–employment cells.

Figure 1 presents the regional distribution of refugees by age group as a share of the employed population, revealing differences both across federal states and between age groups. Bremen, Saxony-Anhalt, and Saarland exhibit the highest shares of young refugees relative to employment, while southern regions, Hamburg, and Mecklenburg-Western Pomerania show the lowest shares. On the other hand, eastern German states like Mecklenburg- Western Pomerania, Berlin, and Saxony have the highest shares of old-age refugees among all federal states. Overall, the total share of Syrian refugees in 2015 as share of the employed persons ranges between 0.2 and 0.3 percent.

3.2 Other data

In order to solve for equilibrium, I need to have data for regional migration flows $\mu_{ij,t}^{n,a,\ell o}$ between regions i and j, labor status today l, and labor status tomorrow o. $L_{n,a,t}^{il}$ denotes the labor distribution of households by nationality n and age group a at time t and is the aggregate of employed and non-employed households. Data comes from the European Labor Force Survey (EU-LFS) and the World Bank World Development Indicators (WDI). Migration flows are between the years 2012 and 2013 and the labor distribution is for year 2013. For a detailed derivation of

Figure 1: Age distribution of Syrian refugees across German NUTS-1 regions, 2015



(a) Refugees aged 15-34 as share of employed population

(b) Refugees aged 35-64 as share of employed population

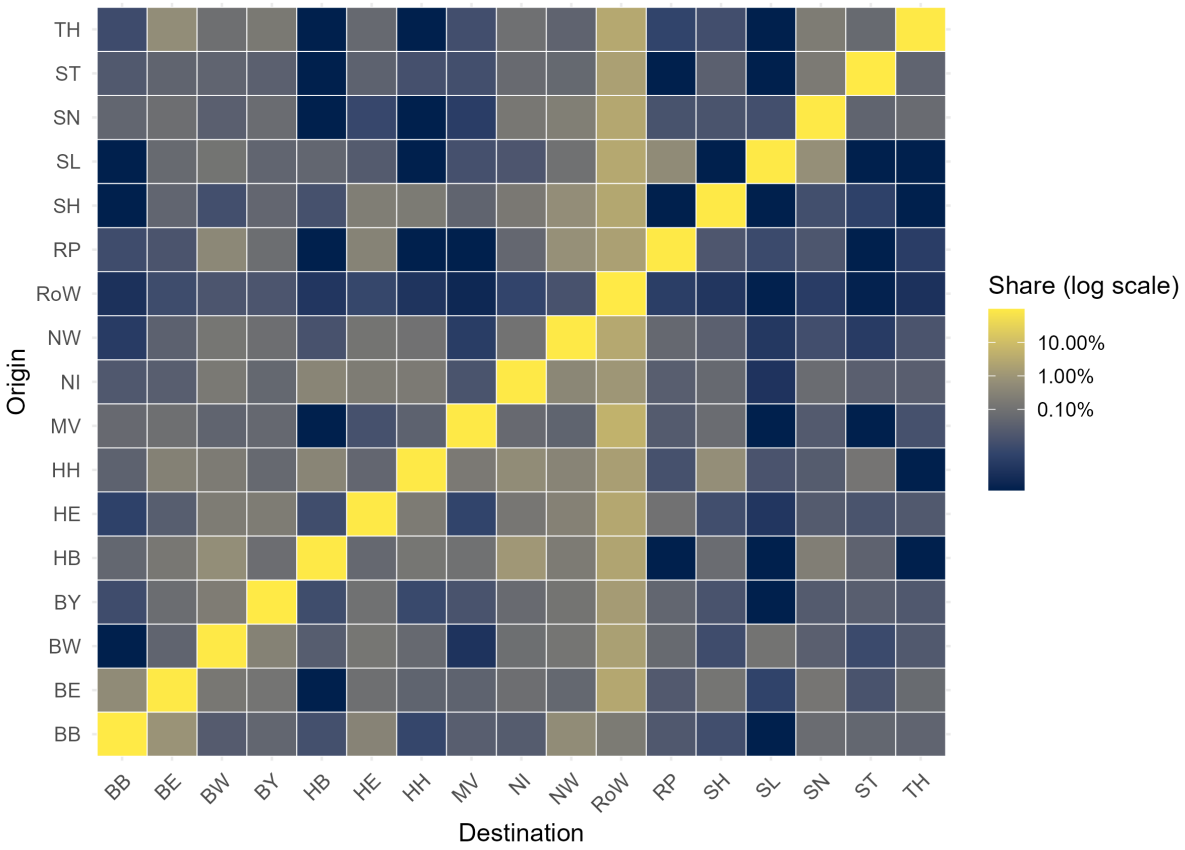
the flows and stocks, refer to the Appendix section B. Figure 2 shows a heatmap of migration shares between regions. Each cell represents the share of people leaving each origin region towards the respective destination region of all people of that origin region. The federal states with highest outmigration rates between 2012 and 2013 are Mecklenburg-Western Pomerania with 5.6 percent, followed by Bremen with 5.1 percent. Thuringia is also one of the top 5 states with high outmigration rates, revealing that 2 out of 5 eastern German states, excluding Berlin, are among the top 5 regions with highest outmigration shares.

Data on the share labor compensation in value added by age group is retrieved from Eurostat. Data for bilateral trade shares is retrieved from the European commission (Thissen et al., 2019) and is for year 2013. Regional data for the real rental rate of capital is based on real values of the net operating surplus and the capital stock and comes from the ARDECO dataset. In line with Caliendo et al. (2023), I set the migration cost elasticity to $1/\nu = 0.5$. Similarly, the elasticity of substitution between young and old-aged workers is set to $\rho = 4$. For the trade elasticity, I adopt the value $\theta = 4.5$. I use a yearly discount factor of $\beta = 0.97$ and a depreciation rate of $\delta = 0.05$.

3.3 Descriptive Analysis

Table 1 reports descriptive statistics for the 16 German federal states, covering economic performance, capital intensity, demographic structure, skill composition, and labor market condition

Figure 2: Migration flows between German NUTS-1 regions and RoW, 2012-2013



Note: RoW corresponds to an aggregated Rest of the world. Source: own calculations, based on EU-LFS.

Table 1: Descriptive Statistics by Region, 2013

Region	GDP p.c. (1000 €)	Population (mill.)	K/L (1000 €)	<30 (%)	>64 (%)	High skill (%)	Unemp.rate (%)
BW	40.89	10.57	225.31	32.12	19.55	30.63	3.36
BY	41.51	12.52	272.01	31.25	19.72	29.59	3.04
BE	34.40	3.38	182.93	31.38	19.18	37.61	10.39
BB	25.44	2.45	379.20	25.62	22.72	30.36	7.29
HB	45.06	0.65	221.61	31.25	21.34	27.30	7.03
HH	61.11	1.73	256.07	31.89	18.97	32.12	4.74
HE	41.64	6.02	180.69	30.67	20.00	30.92	4.36
MV	23.94	1.60	396.23	26.79	22.29	26.57	10.07
NI	32.36	7.78	241.75	30.59	21.06	24.27	4.90
NW	34.51	17.55	163.62	30.94	20.42	25.90	5.92
RP	31.57	3.99	208.14	30.37	20.47	26.55	4.01
SL	32.50	0.99	215.57	28.18	22.05	23.18	5.97
SN	26.12	4.05	398.72	26.91	24.76	32.81	7.81
ST	24.63	2.26	387.23	25.49	24.57	26.05	9.07
SH	28.64	2.81	199.41	29.66	22.10	24.62	4.89
TH	24.99	2.17	362.13	26.37	23.49	30.14	6.03

in year 2013.

Economic performance, measured as GDP per capita, mirrors these labor market patterns. Hamburg (HH) stands out with the highest GDP per capita of 61.11 thousand euros, followed by Bremen (HB, 45.06 thousand euros) and the southern states Bavaria (BY, 41.51 thousand euros), Hesse (HE, 41.64 thousand euros), and Baden-Württemberg (BW, 40.89 thousand euros). In contrast, GDP per capita is lowest in eastern German states, as in Mecklenburg-Western Pomerania (MV, 23.94 thousand euros), Saxony-Anhalt (ST, 24.63 thousand euros), and Thuringia (TH, 24.99 thousand euros).

Capital intensity (K/L), exhibits substantial cross-regional variation and displays a striking east–west pattern. The highest capital intensities are observed in the eastern states, notably Saxony (SN, 398.72 thousand euros per worker), Mecklenburg-Western Pomerania (MV, 396.23), Saxony-Anhalt (ST, 387.23), Brandenburg (BB, 379.20), and Thuringia (TH, 362.13). By contrast, several large western states show markedly lower capital–labor ratios, including North Rhine–Westphalia (NW, 163.62) and Hesse (HE, 180.69), while Baden-Württemberg (BW, 225.31) and Bavaria (BY, 272.01) lie in the mid-to-upper range among western regions.

This pattern suggests that eastern states, despite lower GDP per capita, are relatively capital intensive in per-worker terms, reflecting their smaller labor forces and post-reunification investment dynamics. Conversely, economically large western states combine high output levels with comparatively lower capital intensity, indicating a stronger role for labor input in production.

These structural differences in initial capital labor ratios are likely to shape regional adjustment dynamics in response to labor-supply shocks, as regions with higher capital intensity may experience different wage and return responses than more labor-intensive economies.

Population size varies substantially across regions, ranging from 0.65 million in Bremen (HB) to 17.55 million in North Rhine–Westphalia (NW). The southern states Baden-Württemberg (BW) and Bavaria (BY) are also among the most populous, with 10.57 and 12.52 million inhabitants, respectively.

The age distribution reveals systematic differences among regions. The share of individuals younger than 29 ranges from about 25–27 percent in several eastern states (e.g., Brandenburg (BB), Saxony (SN), Saxony-Anhalt (ST), and Thuringia (TH)) to around 32 percent in Baden-Württemberg, followed by Hamburg (HH) and Berlin (BE) with 31 percent. The proportion aged 65 and above is highest in eastern states such as Saxony (24.76 percent) and Saxony-Anhalt (24.57 percent), and lowest in Hamburg (18.97 percent) and Berlin (19.18 percent), indicating comparatively older populations in eastern German states.

Skill composition also differs markedly. The share of high-skilled workers ranges from 23.18 percent in Saarland (SL) and 24.27 percent in Lower Saxony (NI) to 37.61 percent in Berlin (BE), which exhibits the highest concentration of high-skilled workers. Most other regions cluster around 26–32 percent high-skilled employment.

Unemployment rates show pronounced regional disparities. They are lowest in Bavaria (BY, 3.04 percent) and Baden-Württemberg (3.36 percent), and highest in Berlin (BE, 10.39 percent) and Mecklenburg-Western Pomerania (MV, 10.07 percent). Other eastern states (e.g., Saxony-Anhalt, ST, 9.07 percent; Saxony, SN, 7.81 percent) also exhibit above-average unemployment compared to most western regions.

Overall, the table highlights substantial heterogeneity across German federal states in terms of demographic structure, human capital, unemployment, and economic output, with southern and city states generally exhibiting more favorable labor market outcomes and higher income levels than several eastern regions.

4 Results

Figure 3 reports the regional effects of the labor-supply shock relative to the baseline equilibrium across German NUTS-1 regions. Overall, the shock generates positive aggregate effects in all regions, though with some heterogeneity in magnitude.

In all regions, real GDP increases relative to baseline. The magnitude of the effect ranges from about 0.10 to 1.12 percent. For most regions, GDP gains remain modest and lie between roughly 0.12 and 0.38 percent. The largest increases are observed in Hamburg (0.38 percent), Bremen

(0.30 percent), and Mecklenburg- Western Pomerania (0.26 percent).In Saxony- Anhalt, GDP rises by about 1.12 percent, exceeding the effects in other regions.

Overall, no region experiences an aggregate decline in GDP. Even regions with relatively small inflows or net outmigration display slightly positive output effects. This suggests that general equilibrium spillovers through trade and capital accumulation are strong enough to prevent regional output losses, even where employment responses are weak or negative.

Spatially, the map indicates that GDP gains are broadly distributed across the country, with particularly strong effects in small to medium-sized regions. The pronounced increase in Saxony-Anhalt stands out relative to the otherwise moderate distribution of gains. This pattern reflects the interaction between the regional allocation of the labor-supply shock, endogenous internal migration, and trade linkages embedded in the Eaton–Kortum structure.

Capital stocks increase in all regions. Relative changes range from about 0.10 percent to 1.13 percent, closely mirroring the pattern observed for GDP. Again, Saxony-Anhalt exhibits the strongest capital deepening (around 1.13 percent), while most other regions record increases between 0.12 and 0.38 percent.

This pattern is consistent with the model's transitional dynamics. The unanticipated labor-supply shock initially raises the labor-to-capital ratio and increases the real rental rate of capital. Forward-looking capital owners respond by raising investment, which gradually expands the regional capital stock. Regions with more persistent output gains therefore display more pronounced capital deepening in steady state.

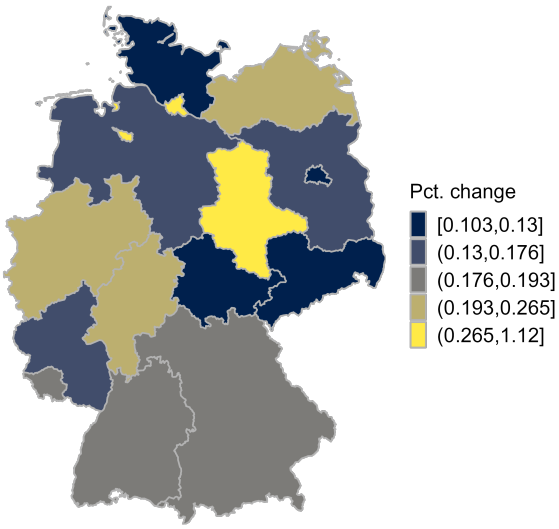
Employment responses, measured in thousand persons relative to baseline, display considerably more heterogeneity and include both positive and negative changes. The largest absolute employment increase occurs in North Rhine-Westphalia, with roughly 15.9 thousand additional employed persons. Other notable gains are observed in Hesse (around 4.4 thousand), Schleswig-Holstein (about 1.8 thousand), and Mecklenburg- Western Pomerania (about 1.8 thousand).

At the same time, a number of regions experience employment declines despite positive GDP effects. The largest reductions occur in Hamburg (around - 12.5 thousand), Bavaria (approximately -7.6 thousand), and Berlin (about -4.8 thousand).

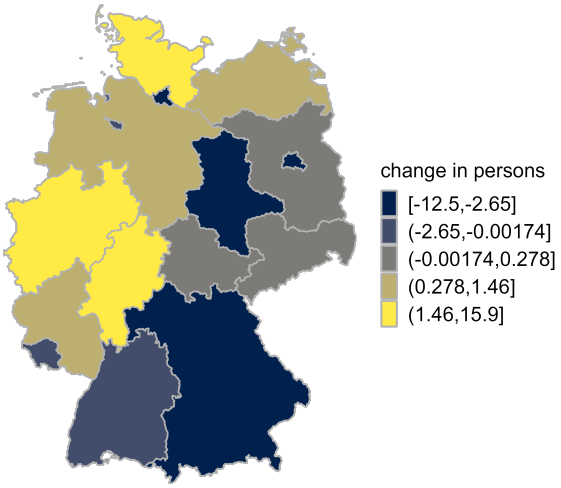
These patterns reflect internal reallocation mechanisms. Workers respond to differences in expected utility across regions, leading to endogenous migration flows that amplify employment gains in some regions while reducing employment in others. As a result, regional employment effects do not mechanically mirror the initial refugee allocation but incorporate endogenous migration responses.

Overall, the positive co-movement of GDP and capital across all regions underscores the importance of endogenous capital adjustment in response to the labor-supply shock. Gradual capital

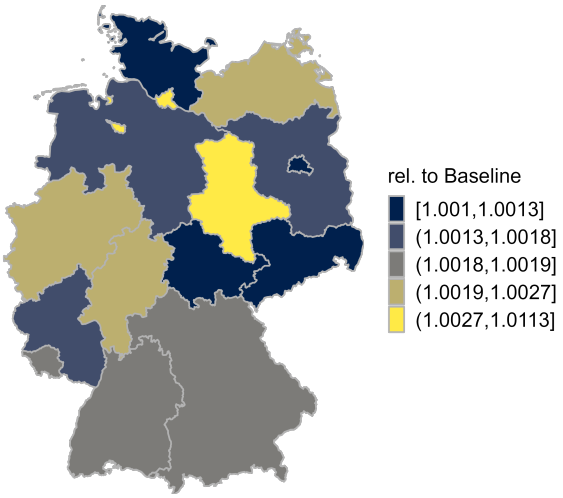
Figure 3: Regional counterfactual effects relative to baseline



(a) GDP change (%)



(b) Employment change (in persons)



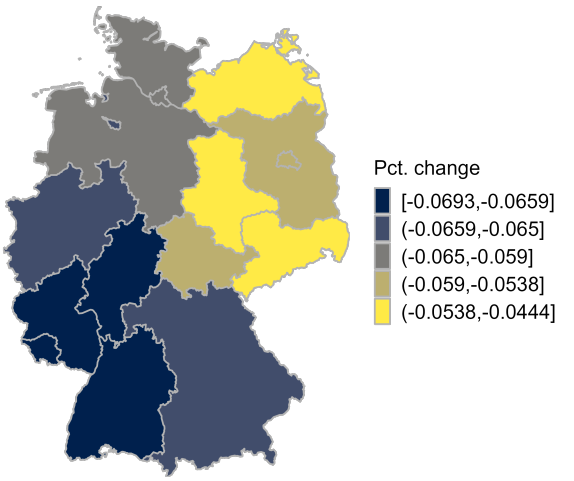
(c) Capital stock change (relative to baseline)

accumulation amplifies the long-run output effects, and helps sustain positive production responses even in regions experiencing net employment losses due to internal migration.

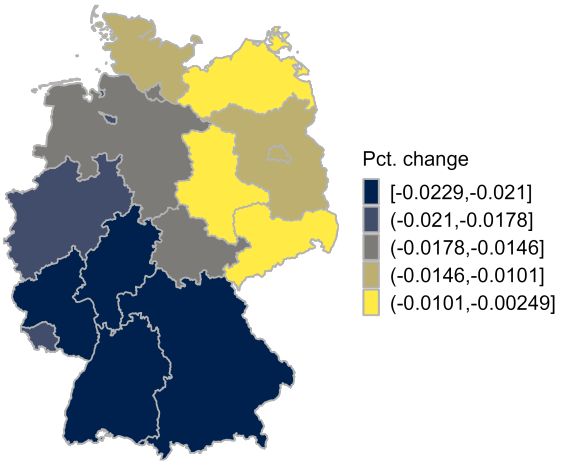
Figure 4 reports welfare changes in percent relative to baseline by age group and for capital owners across German NUTS-1 regions.

For households aged 15-34, welfare effects are negative in every region, though quantitatively

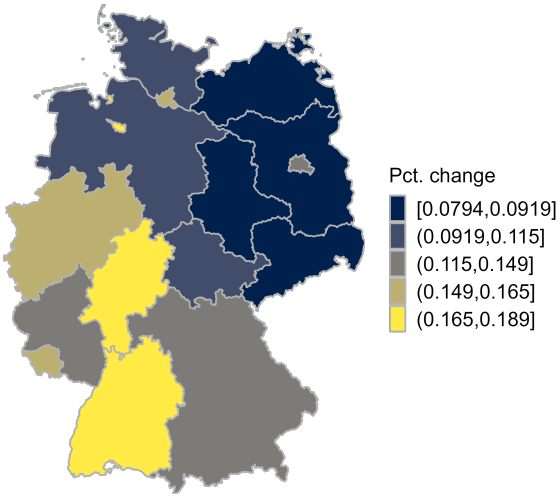
Figure 4: Regional counterfactual effects relative to baseline



(a) Households aged 15-34 (%)



(b) Households aged 35-64 (%)



(c) Capitalists (%)

small. Losses range between -0.044 and -0.069 percent. The strongest declines are observed in Baden-Württemberg (-0.069 percent) and Hesse (-0.069 percent). The smallest losses occur in Mecklenburg-Western Pomerania (-0.044 percent).

For households aged 35-64, welfare losses are again negative in all regions but substantially smaller in magnitude. Declines range from about -0.002 to -0.023 percent. The largest reduction is observed in Baden-Württemberg (-0.023 percent), followed closely by Bavaria (-0.023 percent). The smallest losses occur in Saxony-Anhalt (-0.002 percent) and Saxony (-0.005 percent).

Overall, the magnitude of the welfare decline for younger households is systematically larger than for older households across all regions. Younger households have a longer expected working horizon and therefore place greater weight on the future path of wages in their value function. The initial wage decline induced by the labor-supply shock, even if gradually mitigated by capital accumulation, lowers the discounted lifetime utility of younger cohorts more strongly.

Looking at the distributional effects for households from a spatial perspective, eastern regions experience smaller welfare losses across both age groups, compared to western German states. This pattern reflects the demographic structure of those regions, which are structurally older and have relatively higher baseline outmigration rates. Consistent with this, labor market competition among incumbent households and inflows is weaker and, in some cases, net outmigration dampens the local increase in labor supply and mitigates downward pressure on wages.

In contrast, capital owners experience welfare gains in all regions. Gains range between 0.08 in Brandenburg and 0.17 percent in Bremen. Positive welfare effects for capital owners thus exceed the welfare losses incurred by households across all regions and age groups.

The positive pattern for capitalists reflects the increase in the real rental rate of capital following the labor-supply shock. In the short run, the higher labor-to-capital ratio raises the marginal product of capital. Forward-looking capitalists anticipate higher returns and increase investment, which expands the capital stock over time. Even though capital accumulation gradually dampens rental rates, capital owners benefit from the transitional increase in returns and from higher aggregate output in the long run.

Capitalist welfare gains are somewhat smaller in eastern regions compared to western German states. This pattern is consistent with their substantially higher baseline capital–labor ratios (see Table 1). In capital-abundant regions, the labor-supply shock induces a smaller proportional increase in the labor-to-capital ratio and therefore a more muted rise in the marginal product of capital. As a result, rental rate increases, and hence capitalist welfare gains, are smaller compared to more labor-intensive western regions.

Although the magnitudes are modest, the pattern is robust across regions: even after capital has fully adjusted, the new steady state features a modest redistribution from labor to capital

Table 2: Determinants of Regional GDP, Wage, and Capital Income Responses to Immigration

	Conv. Speed (%)	ΔWage young	ΔCapital income(%)	ΔGDP(%)
Intercept	25.551	−0.185	0.104***	2.094
	(16.352)	(0.135)	(0.017)	(1.970)
Population share < 29	−0.367	0.004		−0.076
	(0.538)	(0.004)		(0.067)
GDP per capita	−0.093	0.000		0.013*
	(0.068)	(0.001)		(0.005)
Capital–labor ratio	−0.027*			0.000
	(0.010)			(0.001)
Conv. speed (%)		0.007+		
		(0.004)		
Δ Wage young			−4.923***	
			(0.423)	
Num.Obs.	16	16	16	16
R2	0.411	0.456	0.856	0.194
R2 Adj.	0.264	0.320	0.845	−0.007
Standard errors	HC1	HC1	HC1	HC1

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Note: ΔWage young = ΔWage young (%) × 10^3

income, with young and middle-aged workers bearing small welfare losses and capital owners realizing small gains.

Taken together, these results point to a consistent pattern across regions: even after capital has fully adjusted and the economy reaches its new steady state, the labor-supply shock leaves a small but persistent redistribution from labor to capital income. Younger and middle-aged workers bear small welfare losses, reflecting their exposure to the initial wage decline, while capital owners retain small gains due to the temporarily elevated rental rate and the long-run expansion of the capital stock.

5 Mechanisms

To better understand the sources of regional heterogeneity in the output effects of refugee immigration, this section examines the mechanisms operating in the model. In particular, I investigate how regional characteristics relate to adjustment dynamics, wage responses, and capital income changes that ultimately determine regional output effects.

Table 2 reports cross-regional regressions linking simulated convergence speeds, wage changes, capital income responses, and GDP differences between the counterfactual and baseline scenarios to initial regional characteristics and transition dynamics. All simulated variables are

averaged over the entire simulation horizon.

Column (1) examines the determinants of the regional convergence speed toward the new equilibrium following the immigration shock, as adjustment paths might determine the size of long-term gains. The convergence speed is estimated from a timeseries regression that measures how quickly the gap between GDP of the counterfactual and the baseline scenario closes:

$$g_t = \log\left(\frac{\text{GDP}_t^{CF}}{\text{GDP}_t^{B}}\right) \tag{13}$$

$$\Delta g_t = \alpha + \beta g_{t-1} + \varepsilon_t \tag{14}$$

where $-\beta$ is the estimated speed of convergence.

The results suggest that regions with higher capital–labor ratios tend to adjust more slowly. This pattern is consistent with the idea that capital-intensive regional economies require more time to absorb additional labor supply, as capital accumulation and reallocation occur gradually over the transition path. In contrast, demographic structure and income levels do not appear to be systematically associated with convergence speeds.

Column (2) relates the regional wage responses of young workers to initial characteristics and adjustment dynamics. Because the labor-supply shock primarily affects younger labor market participants and welfare losses are concentrated among younger households (see Figure 4), the regression analysis focuses on wage changes for the young cohort. The dependent variable measures the average change in real wages of young workers relative to the baseline equilibrium. The results indicate that wage responses are related to the speed of regional transition dynamics. Regions that converge more quickly towards their new equilibrium experience smaller wage declines following the immigration shock. Demographic structure and initial income levels, by contrast, show little systematic association with wage responses. These findings suggest that differences in regional adjustment dynamics rather than differences in initial economic structure drive the heterogeneity in wage responses across regions.

Column (3) investigates the relationship between wage changes and capital income responses. The results reveal a strong negative association between the two variables: regions experiencing larger wage declines also exhibit larger increases in capital income. The regression explains a large share of the cross-regional variation in capital income responses. This pattern is consistent with the mechanism embedded in the model. An increase in labor supply reduces equilibrium wages while increasing the marginal product of capital. As a result, regions experiencing larger wage adjustments also experience stronger increases in capital income.

Finally, column (4) relates the simulated GDP gains to initial regional characteristics. Although the explanatory power of this regression is limited, GDP per capita shows a positive association

with output gains, suggesting that relatively richer regions tend to experience somewhat larger GDP increases following the immigration shock.

Taken together, the results point to the following mechanism. Refugee immigration increases labor supply across all regions. Differences in regional adjustment dynamics lead to heterogeneous wage responses along the transition path. Regions that adjust more slowly experience larger temporary wage declines, which increase the marginal product of capital and generate stronger capital income gains. Through this channel, differences in wage adjustments and capital income responses contribute to the regional heterogeneity in output gains observed in the counterfactual simulations.

At the same time, initial economic conditions also shape the magnitude of regional output responses. The positive association between GDP per capita and the simulated GDP gains suggests that relatively more productive regions tend to benefit somewhat more from the immigration-induced expansion of labor supply. Similarly, differences in initial capital intensity affect how strongly the marginal product of capital responds to the labor-supply shock and how quickly capital adjusts during the transition. These initial conditions therefore influence the extent to which the general equilibrium adjustment mechanism translates into regional output gains.

Collectively, the results suggest a clear profile of regions that tend to benefit the most from the labor-supply shock. Relatively richer regions with higher GDP per capita, such as Hamburg, Bremen, and Hesse, generally experience larger GDP gains. High initial capital intensity, as seen in regions like Saxony-Anhalt or Mecklenburg-Western Pomerania, is associated with slower adjustment dynamics following the labor-supply shock. Slower adjustment implies more persistent wage declines during the transition, which in turn raises the marginal product of capital and generates stronger capital income gains. In other words, both initial wealth and the capital–labor structure shape the extent to which regions can translate an influx of labor into higher output.

However, these structural characteristics do not fully account for the observed regional variation in output gains. Some regions with broadly similar initial conditions still exhibit different responses. For example, Saxony and Saxony-Anhalt display comparable levels of GDP per capita and capital intensity, yet the simulated GDP gains are substantially larger in Saxony-Anhalt. These differences reflect additional equilibrium forces embedded in the model. In particular, regional outcomes are shaped not only by local production structures but also by the spatial allocation of the labor-supply shock, endogenous internal migration, and trade linkages across regions. Changes in relative wages and expected utility induce workers to relocate across regions, while trade connections transmit productivity and demand effects across regional economies. As a result, regions with similar initial economic structures may still experience different output responses depending on their position within the national spatial equilibrium.

Overall, the empirical patterns suggest that initial economic conditions help explain the system-

atic component of regional heterogeneity in the output effects of immigration, while migration dynamics and interregional trade generate additional variation around this pattern.

6 Conclusion

This paper studies how an exogenous labor-supply shock interacts with endogenous migration and capital accumulation in a multi-regional general equilibrium framework. Embedding a refugee-induced labor inflow into a dynamic spatial model with heterogeneous age groups, forward-looking migration, and local capital adjustment reveals substantial regional and distributional heterogeneity behind modest aggregate effects.

The results show that the labor-supply shock generates positive output responses across all German regions. Real GDP increases everywhere relative to the baseline equilibrium, though the magnitude of gains varies across space. In most regions, the increases are modest, while a few regions experience more pronounced output gains. Capital stocks expand alongside output in all regions, reflecting the endogenous investment response triggered by the temporary rise in the labor-to-capital ratio.

Regional employment responses are considerably more heterogeneous. While some regions experience employment gains, others see declines due to endogenous internal migration. Workers relocate in response to differences in expected utility across regions, which amplifies employment growth in some areas while reducing it in others. Despite these reallocations, general equilibrium spillovers through trade and capital accumulation ensure that no region experiences a decline in output.

The analysis of the underlying mechanisms shows that regional heterogeneity in output gains arises through differences in transition dynamics, but is also shaped by initial economic conditions. Regions that adjust more quickly toward the new equilibrium experience smaller wage declines following the labor-supply shock. Where wage declines are larger, the marginal product of capital rises more strongly, generating larger increases in capital income and stronger incentives for investment. These capital income responses ultimately drive much of the variation in regional output gains observed in the simulations. At the same time, initial output levels matter: regions with higher GDP per capita tend to experience somewhat larger output gains from the immigration shock. The results suggest that both transition dynamics and initial regional output shape how the labor-supply shock translates into regional economic outcomes.

In addition to aggregate regional heterogeneity, the labor-supply shock generates modest but systematic distributional effects across households. Younger and middle-aged workers experience small welfare losses in all regions, reflecting their longer exposure to the initial wage decline during the transition. In contrast, capital owners benefit from higher returns to capital

following the increase in the labor-to-capital ratio. Although capital accumulation gradually dampens these returns, capitalists retain small welfare gains due to the transitional rise in rental rates and the long-run expansion of the capital stock.

These distributional effects also exhibit a spatial pattern. Welfare losses for workers tend to be smaller in eastern German regions, where older demographic structures and higher baseline outmigration moderate the increase in local labor supply and therefore dampen downward wage pressure. By contrast, capitalist welfare gains are generally smaller in these regions, reflecting their relatively high initial capital–labor ratios, which imply a weaker increase in the marginal product of capital following the labor-supply shock. Across regions, the new steady state exhibits a modest shift in income distribution away from labor and toward capital.

Overall, the findings highlight that immigration can generate positive economic effects across all regions while still producing heterogeneous regional and distributional outcomes. In the simulations, the refugee-induced labor supply shock raises output relative to the baseline in every German region, although the magnitude of these gains varies considerably across space. While refugee inflows can partially alleviate demographic pressures at the aggregate level, they tend to reinforce existing spatial disparities when migration and capital adjustment favor already productive regions. At the same time, the simulations indicate that some regions with relatively high capital intensity may experience stronger output gains, as slower adjustment dynamics generate larger temporary wage declines and stronger incentives for capital accumulation. Agglomeration forces and internal migration responses nevertheless limit the extent to which labor-supply shocks translate into sustained economic gains in many demographically older or economically weaker regions. Policies that facilitate capital formation and labor-market integration may therefore play an important role in smoothing regional adjustment and ensuring that the economic benefits of immigration are broadly shared across regions and households.

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A Model diagnostics: Multinomial logistic Regression

Table 3 reports posterior summaries of the multinomial logistic regression for the age- employment categories. It includes intercepts, slopes for GDP and tertiary education share, and the standard deviation of region-level random intercepts. $\hat{R} \approx 1$ and large effective sample sizes indicate a satisfactory fit.

Table 3: Model Diagnostics — Age × Employment Groups

parameter	Estimate	Est.Error	95% CI	Rhat	Bulk_ESS
Intercept — Old, unemployed	1.629	0.679	0.334 — 2.976	1.000	5234
Intercept — Young, employed	-0.144	0.889	-1.953 — 1.514	1.000	5663
Intercept — Young, unemployed	1.923	0.668	0.661 — 3.282	1.000	5384
GDP per capita — Old, unemployed	0.058	0.398	-0.705 — 0.848	1.000	8378
Tertiary education share — Old, unemployed	0.109	0.430	-0.742 — 0.951	1.002	8365
GDP per capita — Young, employed	-0.030	0.463	-0.959 — 0.854	1.000	10571
Tertiary education share — Young, employed	0.037	0.462	-0.888 — 0.951	1.000	10588
GDP per capita — Young, unemployed	0.115	0.408	-0.671 — 0.931	1.001	8097
Tertiary education share — Young, unemployed	-0.121	0.423	-0.962 — 0.697	1.001	6791
SD (region effect) — Old, unemployed	0.417	0.345	0.018 — 1.263	1.001	3851
SD (region effect) — Young, employed	0.718	0.592	0.025 — 2.213	1.002	3151
SD (region effect) — Young, unemployed	0.355	0.286	0.012 — 1.082	1.001	4356

B Construction of labor stocks and migration flows

I construct data on migration stocks and gross flows by country of origin and destination, nationality, education level, labor force status, and year using microdata from the *European Labour Force Survey* (EU-LFS), version 1, released November 2021, covering data up to 2020. For each respondent, the EU-LFS reports the current country of residence, the country of residence 12 months earlier, the interview year, demographic characteristics, labor force status, education, nationality, and sampling weights that ensure national representativeness.

I define the destination country as the country where the interview is conducted and the origin country as the country of residence one year before the interview. Individuals aged 15–64 are classified as migrants if their origin and destination countries differ. Education is grouped into high- and low-skill categories, and labor force status is measured using current employment status in the destination country and reported status one year earlier.

The EU-LFS allows us to measure the stock of individuals in country i at time $t-1$, by nationality, skill, and labor force status, and to construct gross migration flows between countries from $t-1$ to t. For countries covered by the survey, stocks are measured using both contemporaneous survey information and subsequent-year surveys reporting immigrants residing in the country one year earlier. When multiple measures are available, I reconcile them to ensure internal consistency.

Flows from EU countries to the rest of the world are not directly observed in the EU-LFS and are therefore inferred indirectly. Specifically, for each origin region, nationality, skill level, and labor force status, I compare population stocks measured in two consecutive EU-LFS waves. After accounting for all observed intra- EU region migration flows, any remaining decline in the population stock is interpreted as emigration to destinations outside the EU. To ensure internal consistency, cases in which the later survey implies a larger stock than the earlier survey are attributed to measurement error and absorbed by updating the stock measure rather than generating negative flows.

Since labor force status at non-EU destinations is not observed, inferred flows to the rest of the world are further allocated across destination employment states using average labor market distributions. These distributions are constructed by combining working-age population data from the World Bank World Development Indicators with employment and skill shares observed in the EU-LFS, separately by nationality and skill group.

To construct the Rest-of-World (RoW) population stocks, I use total population levels and working-age population shares from the World Bank World Development Indicators. I then split these stocks by nationality, skill level, and labor-force status using the average shares observed in the EU-LFS sample regions. Specifically, a share of the RoW population equal to the size of the working-age population in the European sample regions is assigned the average skill–employment distribution of EU citizens in the LFS. The remaining population is allocated to an "Other" nationality group, with skill-employment shares matched to those observed among "Other" nationals in the EU-LFS.

Finally, some origin–destination–nationality–skill–year flow cells are zero due to measurement error or limited sample size. To avoid spurious zeros, we replace such values with small positive numbers equal to the minimum observed migration share conditional on nationality, skill, labor force status in $t-1$ and t, and year.