Commuting, Migration and Trade among Regions in Response to the Termination of the Derogation Period after EU Enlargement

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Abstract

For small open economies the delivery of output and factor services across national borders is of significant quantitative importance. Especially, this is the case within deep free-trade agreements such as the European Union (EU). We set up a quantitative spatial model to assess the magnitude of the consequences free factor movement associated with the Eastern Enlargement of the EU for Austria, which shares more than XX% of its borders with member countries that joined the EU in 2004. XXX

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1 The model

We consider a discrete dynamic spatial quantitative model with J regions and S sectors building on Caliendo, Parro, Dvorkin (2019, Econometria). Within each period our model features sectors with heterogeneous varieties that are produced under perfect competition, with constant returns to scale by combining labor, land and intermediates with productivities drawn from a probabilistic distribution as in Eaton Kortum (2003) and with trade and input-output linkages as in Caliendo Parro (2015). We extend this framework with commuting between regions similar to Monte, Redding and Rossi-Hansberg (2018, AER) or Krebs and Pflüger (2023, RevIntEcon), i.e. by allowing workers to separate their residence and consumption location from their workplace. Between periods, forward looking workers decide based on individual barrier/amenity draws and real consumption possibilities whether they want to switch to a different residence and/or workplace and whether to switch sectors or not. To capture the mobility effects of the EU enlargement we further distinguish workers by their birth country c and impose different migration barriers dependent on c.

1.1 Migration

Within each period t worker-consumers from each birth country c are describe by triplets ijs (where necessary also ghr or klq) that define their residence location i, workplace j and emploment sector s. Workers maximize expected liftetime utility, which consists of one-period welfare u_{ijs}^{t} in their current commuting triplet ijs in the current period t and discounted, expected future returns from picking any triplet ghr for the next period. The (current and future) lifetime utility $U_{ijs}^{c,t}$ of a worker from birth country c on triplet ijs in period t is therefore

$$U_{ijs}^{c,t} = u_{ijs}^{t} + max_{\{ghr\}} \left\{ \rho E \left[U_{ghr}^{c,t+1} \right] - \kappa_{ijs}^{ghr,c,t+1} + \nu_{ijs} a_{ghr}^{t+1} \right\}, \tag{1}$$

where ρ is the time discount rate, $\kappa_{ijs}^{ghr,c,t+1}$ captures the (additive) costs of switching the commuting relation from the triplet ijs in period t to the triplet ghr in period $t+1$, and a_{ghr}^{t+1} are worker specific (Gumbel distributed) idiosyncratic amenity/ability/cost shocks for commuting triplet ghr in period $t+1$. Finally, ν_{ijs} allows to scale the variance of the idiosyncratic shock. We note that conditional on having picked a specific commuting triplet ijs current consumption levels captured by u_{ijs}^{t} do not depend on the birth country c but future utility does, due to carying migration costs.

In each period workers currently on ijs draw amenities for all possible triplets ghr for the next period. We denote

$$\mathbb{F}(a) = e^{-e^{-a-\bar{a}}} = \Pr\left[a_{ijs,t}^{ghr,t+1} \leq a \right]$$

with $\bar{a} = -\int_0^\infty e^{-x} \log x dx$ being Euler's constant.[1]

[1]Note that there are many different ways of defining Euler's constant and we pick the one most conveniently applied to our transformations (see Appendix !!!).

The resulting expected utility (before amenity draws) in period t, for which we introduce the notation $V_{ijs}^{c,t}$ can be derived as

$$V_{ijs}^{c,t} = E\left[U_{ijs}^{c,t}\right] = u_{ijs}^{c,t} + v_{ijs} \log \sum_{klq} \left(e^{\rho V_{klq}^{c,t+1} - \kappa_{ijs}^{klq,c,t+1}}\right)^{\frac{1}{\nu_{ijs}}} , \tag{2}$$

where, in a slight abuse of notation, we use $\sum_{klq}$ to refer to the sum over all possible commuting triplets. Moreover, the probability of having the highest utility in ghr at time $t+1$, which with an ifinitely divisible mass of workers is also the share $\mu_{ijs}^{ghr,c,t+1}$ of commuters from birth country c currently on ijs that switch to ghr in the next period, becomes

$$\mu_{ijs}^{ghr,c,t+1} = \frac{\left(e^{\rho V_{ghr}^{c,t+1} - \kappa_{ijs}^{ghr,c,t+1}}\right)^{\frac{1}{\nu_{ijs}}}}{\sum_{klq}\left(e^{\rho V_{klq}^{c,t+1} - \kappa_{ijs}^{klq,c,t+1}}\right)^{\frac{1}{\nu_{ijs}}}} . \tag{3}$$

Given these transition shares and the number of workers $L_{ijs}^{c,t}$ on all commutes in period t, we can derive the number of workers from born in c on all commutes in the next period as

$$L_{ijs}^{c,t+1} = \sum_{klq} \mu_{klq}^{ijs,c,t+1} L_{klq}^{c,t} . \tag{4}$$

1.2 Consumers and producers

We next turn to the within period equilibrium and drop the period index t for now, to allow for an easier notation. The within period utility is a logged Cobb-Douglas utility across composites from all S sectors, such that indirect utility for a commuter who works in sector s in location j and resides and consumes in location i is given by

$$u_{ijs} = \log \frac{w_{js}}{\prod_{r=1}^{S} P_{ir}^{\alpha_{ir}}} \quad \text{with} \quad \sum_{r=1}^{S} \alpha_{ir} = 1 , \tag{5}$$

where w_{js} is the wage in sector s and workplace j, P_{ir} the price index of the sector r composite in residence location i and $0 \leq \alpha_{ir} \leq 1$ the sector expenditure shares.

Within each sector s a unit mass of individual varieties can be produced in each location i under perfect competition and with constant returns to scale, by combining labor, land, and intermediates in a Cobb-Douglas production function. Productivities in this process are drawn from a Fréchet distribution with scale parameter T_{is} and shape parameter θ_s and varieties can then be traded among regions subject to an iceberg trade costs, i.e. τ_{ijs} units have to be shipped from sector s in region i in order for one unit to arrive in region j. Sectoral composites, whether used as consumption goods or intermediates, are then combined by consumers and firms using the same CES aggregator with each individual variety sourced from the cheapest supplying region. The average price of a sector s variety in j for products from i then consists of producer mill prices (marginal costs) c_{is}, accounting for average productivities and trade barriers, and is given by

$$p_{ijs} = \tau_{ijs} \frac{c_{is}}{T_{is}} ,$$

with unit marginal costs described by

$$c_{is} = w_{is}^{\gamma_{is}} r_i^{\beta_{is}} \prod_{r=1}^{S} P_{ir}^{\mu_{irs}} \ , \tag{6}$$

where r_i is the unit price of land in i, and γ_{is}, β_{is} and μ_{irs} are the cost shares of labor, land and intermediates from sector r in production. With fixed land endoments H_i and available labor given in the within period equilibrium, market clearing for labor and land implies

$$w_{ir} = \frac{\sum_{r=1}^{S} \gamma_{ir} R_{ir}}{\sum_c \sum_{k=1}^{J} L_{kir}^c} \quad \text{and} \quad r_i = \frac{\sum_{r=1}^{S} \beta_{ir} R_{ir}}{H_i} \ , \tag{7}$$

with revenues of sector s in region i denoted by R_{is}.

Our setup results in aggregate trade flows (in value) of sector s goods sent from location i to location j given by

$$X_{ijs} = \frac{p_{ijs}^{-\theta_s}}{P_{js}^{-\theta_s}} E_{js}$$

where E_{js} is total expenditure on sector s goods in location j. Defining outgoing multilateral resistance (MR) terms Ω_{is} as

$$\Omega_{is} = R_{is} c_{is}^{\theta_s} \tag{8}$$

and a combined productivity and trade freeness measure $\phi_{ijs} = \tau_{ijs}^{-\theta_s} T_{is}^{\theta_s}$, we can rewrite trade flows as

$$X_{ijs} = \phi_{ijs} \frac{R_{is}}{\Omega_{is}} \frac{E_{js}}{P_{js}^{-\theta_s}} \ .$$

Market clearing then requires revenues to equal the sum of all outgoing trade flows, including to the region itself:

$$R_{is} = \sum_{j=1}^{J} X_{ijs} = \sum_{j=1}^{J} \phi_{ijs} \frac{R_{is}}{\Omega_{is}} \frac{E_{js}}{P_{js}^{-\theta_s}}$$

$$\Rightarrow \Omega_{is} = \sum_{j=1}^{J} \phi_{ijs} \frac{E_{js}}{P_{js}^{-\theta_s}} \tag{9}$$

And price indices are pinned down by expenditure being equal to the sum of all incoming trade flows, including from the region itself:

$$E_{js} = \sum_{i=1}^{J} X_{ijs} = \sum_{i=1}^{J} \phi_{ijs} \frac{R_{is}}{\Omega_{is}} \frac{E_{js}}{P_{js}^{-\theta_s}}$$

$$\Rightarrow P_{js} = \left(\sum_{i=1}^{J} \phi_{ijs} \frac{R_{is}}{\Omega_{is}} \right)^{-\frac{1}{\theta_s}} \tag{10}$$

Finally, total expenditure on sector s in location j consists of final demand by immobile land owners, who pay all income into an international portfolio and receive a fixed share ι_j of this portfolio (later calibrated to match initial trade imbalances), demand by resident workers who obtain income at their workplace and demand for intermediate goods by producers. Mathematically,

$$E_{js} = \alpha_{js}\iota_j \sum_{i=1}^{J}\sum_{r=1}^{S} \beta_{ir}R_{ir} + \alpha_{js}\sum_{c}\sum_{r=1}^{S}\sum_{i=1}^{J} L_{jir}^{c} w_{ir} + \sum_{r=1}^{S}\mu_{jsr}R_{jr} \ . \tag{11}$$

1.3 Equilibrium

To ease notation, we define by $\tilde{\Theta}$ the set of all exogenous parameters that we will calibrate below but that are always assumed constant across time, i.e. the Cobb-Douglas demand shares α_{js}, and cost shares γ_{is}, β_{is}, μ_{irs}, the trade elasticities θ_s, the land portfolio shares ι_j, as well as the time discounting factor ρ and variance scaler ν_{ijs} of the migration barrier draws from above. Given this we can define the within period equilibrium of the economy in the following definition. Moreover, we drop indices to refer to all instances of a variable, for example, we use R^t to refer to the set of all variables R_{is}^t, i.e. for all $i \in \{1, ..., J\}$ and $s \in \{1, ..., S\}$.

Definition 1.1. *Given time invariant parameters $\tilde{\Theta}$, the housing stocks H, current trade freeness levels ϕ^t and all commuting flows L^t the within period equilibrium consists of revenues R^t and price indices P^t that solve the rearranged definition of the outgoing MR terms (8) and the price index equation (10)*

$$R_{is}^t = \Omega_{is}^t \left(c_{is}^t\right)^{-\theta_s}$$

$$P_{js}^t = \left(\sum_{i=1}^{J} \phi_{ijs}^t R_{is}^t \left(\Omega_{is}^t\right)^{-1}\right)^{-\frac{1}{\theta_s}}$$

after plugging in equations (6), (7), (9), and (11), i.e.

$$\begin{aligned}
\Omega_{is}^t &= \sum_{j=1}^{J} \phi_{ijs}^t E_{js}^t \left(P_{js}^t\right)^{\theta_s} \\
E_{js}^t &= \alpha_{js}\iota_j \sum_{i=1}^{J}\sum_{r=1}^{S} \beta_{ir}R_{ir}^t + \alpha_{js}\sum_{c}\sum_{r=1}^{S}\sum_{i=1}^{J} L_{jir}^{c,t} w_{ir}^t + \sum_{r=1}^{S}\mu_{jsr}R_{jr}^t \\
c_{is}^t &= \left(w_{is}^t\right)^{\gamma_{is}} \left(r_i^t\right)^{\beta_{is}} \prod_{r} \left(P_{jr}^t\right)^{\mu_{jrs}} \\
w_{ir}^t &= \frac{\sum_r \gamma_{ir} R_{ir}^t}{\sum_c \sum_k L_{kir}^{c,t}} \\
r_i^t &= \frac{\sum_r \beta_{ir} R_{ir}^t}{H_i}
\end{aligned}$$

From now on, we denote the set of endogeneous variables of the within period equation system in period t as $\mathbb{Q}^t = \{R^t, P^t, \Omega^t, E^t, c^t, w^t, r^t\}$. We then use the notation $\mathbb{Q}^t\left(\tilde{\Theta}, H, \phi^t, L^t\right)$

to imply that these variables can be solved for in period t given all parameters and commuting flows as described in Definition 1. Using this notation we can define the dynamic equilibrium as follows.

Definition 1.2. *Given time invariant parameters $\tilde{\Theta}$, the housing stocks H, a sequence of trade freeness levels ϕ^t and migration barriers κ^t for all $t = \{0, 1, ...\}$, as well initial values L^0, the dynamic equilibrium consists of a sequence of expected utility levels V^t and commuting flows L^t that solve the migration conditions (2) and (4)*

$$V_{ijs}^{c,t+1} = \log w_{js}^{t+1} \prod_{r=1}^{S} \left(P_{ir}^{t+1}\right)^{-\alpha_{ir}} + \upsilon_{ijs} \log \sum_{klq} \left(e^{\rho V_{klq}^{c,t+2} - \kappa_{ijs}^{klq,c,t+2}}\right)^{\frac{1}{\nu_{ijs}}}$$

$$L_{ijs}^{c,t+1} = \sum_{klq} \mu_{klq}^{ijs,c,t+1} L_{klq}^{c,t}$$

after pluggin in equation (3)

$$\mu_{ijs}^{ghr,c,t+1} = \frac{\left(e^{\rho V_{ghr}^{c,t+1} - \kappa_{ijs}^{ghr,c,t+1}}\right)^{\frac{1}{\nu_{ijs}}}}{\sum_{klq} \left(e^{\rho V_{klq}^{c,t+1} - \kappa_{ijs}^{klq,c,t+1}}\right)^{\frac{1}{\nu_{ijs}}}}$$

and the sequential solutions of the within period problems $\mathbb{Q}^t\left(\tilde{\Theta}, H, \phi^t, L^t\right)$.

1.3.1 Dynamic hat algebra

We define intertemporal changes of variables as $\dot{x}^{t+1} = x^{t+1}/x^t$. Furthermore, let $\tilde{U}_{ijs}^{c,t} = e^{V_{ijs}^{c,t}}$ and $\tilde{\kappa}_{ijs}^{klq,c,t} = e^{\kappa_{ijs}^{klq,c,t}}$. Using $X_{ijs} = \phi_{ijs} \frac{R_{is}}{\Omega_{is}} \frac{E_{js}}{P_{js}^{-\theta_s}} \Rightarrow \frac{X_{ijs}}{R_{is} E_{js}} \frac{\Omega_{is} P_{js}^{-\theta_s}}{\phi_{ijs}} = 1$ we can then restate the equilibrium in terms of relative intertemporal changes as follows.

Definition 1.3. *Given time invariant parameters $\tilde{\Theta}$, a sequence of intertemporal changes in trade freeness levels $\dot{\phi}^t$ and exponentiated migration barriers $\dot{\tilde{\kappa}}^t$ for all $t = \{1, ...\}$, as well as initial trade flows X^0, commuting flows L^0 and migration flows μ^0, the dynamic equilibrium in intertemporal changes consists of a series of $\dot{\tilde{U}}^t$ and L^t that solve the intertemporal migration conditions*

$$\dot{\tilde{U}}_{ijs}^{c,t+1} = \dot{w}_{js}^{t+1} \prod_{r=1}^{S} \left(\dot{P}_{ir}^{t+1}\right)^{\alpha_{ir}} \left(\sum_{klq} \left(\dot{\tilde{U}}_{klq}^{t+2,c}\right)^{\frac{\rho}{\nu_{ijs}}} \left(\dot{\tilde{\kappa}}_{ijs}^{klq,t+2,c}\right)^{-\frac{1}{\nu_{ijs}}} \mu_{ijs}^{klq,c,t+1}\right)^{\upsilon_{ijs}}$$

$$L_{ijs}^{c,t+1} = \sum_{klq} \mu_{klq}^{ijs,c,t} \dot{\mu}_{ijs}^{ghr,c,t+1} L_{klq}^{c,t}$$

after plugging in intertemporal changs in migration shares

$$\dot{\mu}_{ijs}^{ghr,c,t+1} = \frac{\left(\dot{\tilde{U}}_{ghr}^{c,t+1}\right)^{\frac{\rho}{\nu_{ijs}}} \left(\dot{\tilde{\kappa}}_{ijs}^{ghr,c,t+1}\right)^{-\frac{1}{\nu_{ijs}}}}{\sum_{klq} \mu_{ijs}^{klq,c,t} \left(\dot{\tilde{U}}_{klq}^{c,t+1}\right)^{\frac{\rho}{\nu_{ijs}}} \left(\dot{\tilde{\kappa}}_{ijs}^{klq,c,t+1}\right)^{-\frac{1}{\nu_{ijs}}}}$$

as well as the intertemporal solutions $\dot{\mathbb{Q}}^{t+1}\left(\tilde{\Theta}, \dot{\phi}^{t+1}, L^t, L^{t+1}, X^t\right)$ *from solving*

$$\dot{R}_{is}^{t+1} = \dot{\Omega}_{is}^{t+1}\left(\dot{c}_{is}^{t+1}\right)^{-\theta_s}$$

$$P_{js}^{t+1} = \left(\sum_{i=1}^{J} \frac{X_{ijs}^t}{E_{js}^t}\dot{\phi}_{ijs}^{t+1}\frac{\dot{R}_{is}^{t+1}}{\dot{\Omega}_{is}^{t+1}}\right)^{-\frac{1}{\theta_s}}$$

after plugging in

$$\dot{\Omega}_{is}^{t+1} = \sum_{j=1}^{J} \frac{X_{ijs}^t}{R_{is}^t}\dot{\phi}_{ijs}^{t+1}\frac{\dot{E}_{js}^{t+1}}{\left(\dot{P}_{js}^{t+1}\right)^{-\theta_s}}$$

$$\dot{E}_{js}^{t+1} = \frac{\alpha_{js}\iota_j\sum_i\sum_r \beta_{ir}R_{ir}^t\dot{R}_{ir}^{t+1} + \alpha_{js}\sum_r\sum_i L_{jir}^{c,t+1}\dot{L}_{jir}^{c,t+1}w_{ir}^{t+1}\dot{w}_{ir}^{t+1} + \sum_r \mu_{jsr}R_{jr}\dot{R}_{jr}^{t+1}}{\alpha_{js}\iota_j\sum_i\sum_r \beta_{ir}R_{ir}^t + \alpha_{js}\sum_r\sum_i L_{jir}w_{ir}^t + \sum_r \mu_{jsr}R_{jr}^t}$$

$$\dot{c}_{is}^{t+1} = \left(\dot{w}_{is}^{t+1}\right)^{\gamma_{is}}\left(\dot{r}_i^{t+1}\right)^{\beta_{is}}\prod_{r=1}^{S}\left(P_{jr}^{t+1}\right)^{\mu_{jrs}}$$

$$\dot{w}_{ir}^{t+1} = \frac{\sum_r \gamma_{ir}R_{ir}^t\dot{R}_{jr}^{t+1}}{\sum_r \gamma_{ir}R_{ir}^t}\frac{\sum_c\sum_k L_{kir}^{c,t}}{\sum_c\sum_k L_{kir}^{c,t+1}}$$

$$\dot{r}_i^{t+1} = \frac{\sum_r \beta_{ir}R_{ir}^t\dot{R}_{jr}^{t+1}}{\sum_r \beta_{ir}R_{ir}^t}$$

Note in particular that while the intertemporal solution additionally conditions on easily observable initial trade and migration flows, it does no longer require to set the land endowments H or the levels of trade barriers ϕ^t and migration barriers $\tilde{\kappa}^t$, but only their changes.

Finally, we want to compare the development of a baseline economy where, for example, shocks are such that the observed outcomes are replicated over time, to the development of a counterfactual economy in which an unexpected shock to (all future) trade or migration barriers occurs. Specifically, we assume that in $t = 0$ agents have chosen their commutes and obtain utility based on their foresight of the original (baseline) development of all future trade and migration barriers, and subsequently chose their $t = 1$ commutes the same as in the baseline, $\mu_1' = \mu_1$. Then, however, the expected future development of barriers changes unexpectedly and further expected utility levels and migration decisions are based on consumers foresight of this new sequence of barriers. We write variables in the counterfactual with a prime, and define the relative difference between counterfactual developments over time, relative to baseline developments of any variable as: $\hat{x}^t = \dot{x}'^t/\dot{x}^t$. Using this notation we can derive counterfactual development in the following way.

Definition 1.4. *Given time invariant parameters* $\tilde{\Theta}$*, a sequence of counterfactual developments in intertemporal changes in trade freeness levels* $\hat{\dot{\phi}}^t$ *and in migration barriers* $\hat{\dot{\tilde{\kappa}}}^t$ *for all* $t = \{1, ...\}$*, as well as the development of a baseline economy consistent of sequences of*

$\dot{\tilde{U}}^t$, L^t and $\dot{\mathbb{Q}}^t$, the counterfactual equilibrium consists of sequences $\hat{\tilde{U}}^t$ and $(L')^t$ that solve the migration conditions in changes

$$\hat{\tilde{U}}_{ijs}^{c,t+1} = \hat{w}_{js}^{t+1} \prod_{r=1}^{S} \left(\hat{P}_{ir}^{t+1}\right)^{\alpha_{ir}} \left(\sum_{klq} \mu_{ijs}^{\prime klq,c,t+1} \dot{\mu}_{ijs}^{ghr,c,t+2} \left(\hat{\tilde{U}}_{klq}^{t+2,c}\right)^{\frac{\rho}{\nu_{ijs}}} \left(\hat{\tilde{\kappa}}_{ijs}^{klq,t+2,c}\right)^{-\frac{1}{\nu_{ijs}}} \right)^{v_{ijs}}$$

$$L_{ijs}^{\prime c,t+1} = \sum_{klq} \mu_{klq}^{\prime ijs,c,t+1} L_{klq}^{\prime c,t}$$

after plugging in the counterfactual migration shares

$$\dot{\mu}_{ijs}^{\prime ghr,c,t+1} = \frac{\dot{\mu}_{ijs}^{ghr,c,t+1} \left(\hat{\tilde{U}}_{ghr}^{c,t+1}\right)^{\frac{\rho}{\nu_{ijs}}} \left(\hat{\tilde{\kappa}}_{ijs}^{ghr,c,t+1}\right)^{-\frac{1}{\nu_{ijs}}}}{\sum_{klq} \mu_{ijs}^{\prime klq,c,t} \dot{\mu}_{ijs}^{klq,c,t+1} \left(\hat{\tilde{U}}_{klq}^{c,t+1}\right)^{\frac{\rho}{\nu_{ijs}}} \left(\hat{\tilde{\kappa}}_{ijs}^{klq,c,t+1}\right)^{-\frac{1}{\nu_{ijs}}}}$$

and changes $\hat{\mathbb{Q}}^t \left(\tilde{\Theta}, \dot{\mathbb{Q}}^t, \hat{\phi}^t, (L')^t, (X')^0 = X^0\right)$ obtained from solving the system

$$\hat{R}_{is}^{t+1} = \hat{\Omega}_{is}^{t+1} \left(\hat{c}_{is}^{t+1}\right)^{-\theta_s}$$

$$\hat{P}_{js}^{t+1} = \left(\sum_{i=1}^{J} \frac{X_{ijs}^{\prime t}}{E_{js}^{\prime t}} \frac{\dot{X}_{ijs}^{t+1}}{\dot{E}_{js}^{t+1}} \hat{\phi}_{ijs}^{t+1} \frac{\hat{E}_{is}^{t+1}}{\hat{\Omega}_{is}^{t+1}} \right)^{-\frac{1}{\theta_s}}$$

after plugging in

$$\hat{\Omega}_{is}^{t+1} = \sum_{j=1}^{J} \frac{X_{ijs}^{\prime t}}{R_{is}^{\prime t}} \frac{\dot{X}_{ijs}^{t+1}}{\dot{R}_{is}^{t+1}} \hat{\phi}_{ijs}^{t+1} \frac{\hat{E}_{js}^{t+1}}{\left(\hat{P}_{js}^{t+1}\right)^{-\theta_s}}$$

$$\hat{E}_{js}^{t+1} = \frac{\frac{\alpha_{js}\iota_j \sum_i \sum_r \beta_{ir} R_{ir}^{\prime t} \dot{R}_{ir}^{t+1} \hat{R}_{ir}^{t+1} + \alpha_{js} \sum_r \sum_i L_{jir}^{\prime c,t} \dot{L}_{jir}^{c,t+1} \hat{L}_{jir}^{c,t+1} w_{ir}^{\prime t} \dot{w}_{ir}^{t+1} \hat{w}_{ir}^{t} + \sum_r \mu_{jsr} R_{jr}^{\prime} \dot{R}_{jr}^{t+1} \hat{R}_{jr}^{t+1}}{\alpha_{js}\iota_j \sum_i \sum_r \beta_{ir} R_{ir}^{\prime t} + \alpha_{js} \sum_r \sum_i L_{jir}^{\prime c,t} w_{ir}^{\prime t} + \sum_r \mu_{jsr} R_{jr}^{\prime t}}}{\dot{E}_{js}^{t+1}}$$

$$\hat{c}_{is}^{t+1} = \left(\hat{w}_{is}^{t+1}\right)^{\gamma_{is}} \left(\hat{r}_{i}^{t+1}\right)^{\beta_{is}} \prod_{r=1}^{S} \left(\hat{P}_{jr}^{t+1}\right)^{\mu_{jrs}}$$

$$\hat{w}_{ir}^{t+1} = \frac{\frac{\sum_r \gamma_{ir} R_{ir}^{\prime t} \dot{R}_{ir}^{t+1} \hat{R}_{ir}^{t+1}}{\sum_r \gamma_{ir} R_{ir}^{\prime t}} \frac{\sum_c \sum_k L_{kir}^{\prime c,t}}{\sum_c \sum_k L_{kir}^{\prime c,t+1}}}{\dot{w}_{ir}^{t+1}}$$

$$\hat{r}_{i}^{t+1} = \frac{\frac{\sum_r \beta_{ir} R_{ir}^{\prime t} \dot{R}_{ir}^{t+1} \hat{R}_{ir}^{t+1}}{\sum_r \beta_{ir} R_{ir}^{\prime t}}}{\dot{r}_{i}^{t+1}}$$

2 Appendix

2.1 Additional derivations

The expected (current and future) lifetime utility $U_{ijs}^{c,t}$ of a worker from birth country c on triplet ijs in period t is

$$U_{ijs}^{c,t} = u_{ijs}^{c,t} + max_{\{ghr\}} \left\{ \rho V_{ghr}^{c,t+1} - \kappa_{ijs}^{ghr,c,t+1} + \nu_{ijs} a_{ghr}^{t+1} \right\}$$

and in each period workers currently on ijs draw amenities for all possible triplets ghr for the next period from the Gumbel distribution defined by the CDF

$$\mathbb{F}(a) = e^{-e^{-a-\bar{a}}} = \Pr\left[a_{ijs,t}^{ghr,t+1} \leq a\right],$$

with $\bar{a} = -\int_0^\infty e^{-x} \log x dx$ being Euler's constant.

2.1.1 Expected Utility

The CDF of the net present value of moving to ghr next period is then:

$$\Pr\left[\rho V_{ghr}^{c,t+1} - \kappa_{ijs}^{ghr,t+1} + \nu_{ijs} a_{ghr}^{t+1} \leq V\right] = \Pr\left[a_{ijs,t}^{ghr,t+1} \leq \frac{V - \rho V_{ghr}^{c,t+1} + \kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}\right]$$

$$= \mathbb{F}\left(\frac{V - \rho V_{ghr}^{c,t+1} + \kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}\right) = e^{-e^{-\frac{V-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}-\bar{a}}}$$

and PDF

$$\Pr\left[\rho V_{ghr}^{c,t+1} - \kappa_{ijs}^{ghr,t+1} + \nu_{ijs} a_{ghr}^{t+1} = V\right]$$

$$= \frac{d\mathbb{F}\left(\frac{V-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}\right)}{dV} = e^{-e^{-\frac{V-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}-\bar{a}}} e^{-\frac{V-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}-\bar{a}} \frac{1}{\nu_{ijs}}$$

To derive the ex-ante expected welfare of any worker in ijs we first calculate for any welfare level V the chance that ghr gives exactly this welfare level and all other locations $klq \neq ghr$ provide a lower welfare level (that is, the chance that the consumer will pick ghr and obtain V). We weight the welfare level V with this probability and integrate (and sum) over all potential welfare levels from minus infinity to infinity in all potential locations ghr.

$$E\left[max_{\{ghr\}} \left\{ \rho V_{ghr}^{c,t+1} - \kappa_{ijs}^{ghr,t+1} + \nu_{ijs} a_{ghr}^{t+1} \right\}\right]$$

$$= \sum_{ghr} \int_{-\infty}^{\infty} V \Pr\left[\rho V_{klq}^{c,t+1} - \kappa_{ijs}^{klq,t+1} + \nu_{ijs} a_{klq}^{t+1} \leq V | \forall klq \neq ghr\right] \Pr\left[\rho V_{ghr}^{c,t+1} - \kappa_{ijs}^{ghr,t+1} + \nu_{ijs} a_{ghr}^{t+1} = V\right] dV$$

$$= \sum_{ghr} \int_{-\infty}^{\infty} V \Pi_{klq \neq ghr} \Pr\left[\rho V_{klq}^{c,t+1} - \kappa_{ijs}^{klq,t+1} + \nu_{ijs} a_{klq}^{t+1} \leq V\right] \frac{d\mathbb{F}\left(\frac{V-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}\right)}{dV} dV$$

$$= \sum_{ghr} \int_{-\infty}^{\infty} V \Pi_{klq \neq ghr} e^{-e^{-\frac{V - \rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}}} e^{-e^{-\frac{V - \rho V_{ghr}^{c,t+1} + \kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}} - \bar{a}}} e^{-\frac{V - \rho V_{ghr}^{c,t+1} + \kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}} - \bar{a}} \frac{1}{\nu_{ijs}} dV$$

$$= \sum_{ghr} \int_{-\infty}^{\infty} V e^{\sum_{klq} -e^{-\frac{V - \rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}}} e^{-\frac{V - \rho V_{ghr}^{c,t+1} + \kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}} - \bar{a}} \frac{1}{\nu_{ijs}} dV$$

Define $x(V) = \sum_{klq} e^{-\frac{V - \rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}}$ and thus $dx/dV = -\sum_{klq} \frac{1}{\nu_{ijs}} e^{-\frac{V - \rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}} = -\frac{1}{\nu_{ijs}} x \rightarrow x = -v_{ijs} dx/dV$ and

$$x = \sum_{klq} e^{-\frac{V - \rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}} = e^{-\frac{V}{v_{ijs}}} \sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}}$$

$$\log x = -\frac{V}{v_{ijs}} + \log \sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}}$$

$$V = v_{ijs} \log \sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}} - v_{ijs} \log x$$

Plugging this in

$$\Rightarrow \sum_{ghr} \int_{-\infty}^{\infty} V e^{\sum_{klq} -e^{-\frac{V - \rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}}} e^{-\frac{V - \rho V_{ghr}^{c,t+1} + \kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}} - \bar{a}} \frac{1}{\nu_{ijs}} dV$$

$$= \sum_{ghr} \int_{-\infty}^{\infty} V e^{-x} e^{-\frac{V - \rho V_{ghr}^{c,t+1} + \kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}} - \bar{a}} \frac{1}{\nu_{ijs}} dV$$

$$= \int_{-\infty}^{\infty} V e^{-x} \left(\sum_{ghr} e^{-\frac{V - \rho V_{ghr}^{c,t+1} + \kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}} - \bar{a}} \right) \frac{1}{\nu_{ijs}} dV$$

$$= \int_{-\infty}^{\infty} V e^{-x} x \frac{1}{\nu_{ijs}} dV$$

$$= \int_{x(-\infty)}^{x(\infty)} V e^{-x} x \frac{dV}{dx} \frac{1}{\nu_{ijs}} dx$$

$$= \int_{\infty}^{0} V e^{-x} x \frac{1}{-x} dx$$

$$= \int_{\infty}^{0} -V e^{-x} dx$$

$$= \int_{0}^{\infty} V e^{-x} dx$$

$$= \int_0^\infty \left(v_{ijs} \log \sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}} - v_{ijs} \log x \right) e^{-x} dx$$

$$= v_{ijs} \left(\int_0^\infty e^{-x} \log \sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}} dx - \int_0^\infty e^{-x} \log x dx \right)$$

With $-\int_0^\infty e^{-x} \log x dx$ a representation of Euler's constant $\bar{a}$

$$= v_{ijs} \left(\int_0^\infty e^{-x} \log \sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}} dx + \bar{a} \right)$$

$$= v_{ijs} \left(\left[-e^{-x} \log \sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}} \right]_0^\infty + \bar{a} \right)$$

$$= v_{ijs} \left(\log \sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}} + \bar{a} \right)$$

$$= v_{ijs} \log \sum_{klq} \left(e^{\rho V_{klq}^{c,t+1} - \kappa_{ijs}^{klq,t+1}} \right)^{\frac{1}{\nu_{ijs}}}$$

this implies

$$V_{ijs}^{c,t} = u_{ijs}^t + v_{ijs} \log \sum_{klq} \left(e^{\rho V_{klq}^{c,t+1} - \kappa_{ijs}^{klq,t+1}} \right)^{\frac{1}{\nu_{ijs}}}$$

2.1.2 Migration shares

$$\mu_{ijs}^{ghr,t+1} = \Pr \left[\rho V_{ghr}^{c,t+1} - \kappa_{ijs}^{ghr,t+1} + a_{ijs,t}^{ghr,t+1} > \max \left\{ \rho V_{klq}^{c,t+1} - \kappa_{ijs}^{klq,t+1} + a_{ijs,t}^{klq,t+1}; klq \neq ghr \right\} \right]$$

$$= \int_0^\infty \Pr \left[\rho V_{klq}^{c,t+1} - \kappa_{ijs}^{klq,t+1} + \nu_{ijs} a_{klq}^{t+1} \leq V | \forall klq \neq ghr \right] \Pr \left[\rho V_{ghr}^{c,t+1} - \kappa_{ijs}^{ghr,t+1} + \nu_{ijs} a_{ghr}^{t+1} = V \right] dV$$

$$= \int_0^\infty \Pi_{klq \neq ghr} \Pr \left[\rho V_{klq}^{c,t+1} - \kappa_{ijs}^{klq,t+1} + \nu_{ijs} a_{klq}^{t+1} \leq V \right] \frac{d\mathbb{F}\left(\frac{V - \rho V_{ghr}^{c,t+1} + \kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}} \right)}{dV} dV$$

$$= \int_{-\infty}^\infty e^{\sum_{klq} -e^{-\frac{V - \rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}}} e^{-\frac{V - \rho V_{ghr}^{c,t+1} + \kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}} - \bar{a}} \frac{1}{\nu_{ijs}} dV$$

$$= \int_{-\infty}^\infty e^{\sum_{klq} -e^{-\frac{V - \rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}}} e^{-\frac{V}{\nu_{ijs}}} e^{-\frac{-\rho V_{ghr}^{c,t+1} + \kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}} - \bar{a}} \frac{1}{\nu_{ijs}} dV$$

$$= \frac{e^{-\frac{-\rho V_{ghr}^{c,t+1} + \kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}} - \bar{a}}}{\sum_{klq} -e^{-\frac{-\rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}}} \int_{-\infty}^\infty e^{\sum_{klq} -e^{-\frac{V - \rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}}} e^{-\frac{V}{\nu_{ijs}}} \sum_{klq} -e^{-\frac{-\rho V_{klq}^{c,t+1} + \kappa_{ijs}^{klq,t+1}}{\nu_{ijs}} - \bar{a}} \frac{1}{\nu_{ijs}} dV$$

$$= \frac{e^{-\frac{-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}-\bar{a}}}{\sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq,t+1}}{\nu_{ijs}}-\bar{a}}} \int_{-\infty}^{\infty} e^{\sum_{klq} -e^{-\frac{V-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq}}{\nu_{ijs}}-\bar{a}}} e^{-\frac{V}{\nu_{ijs}}} \sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq}}{\nu_{ijs}}-\bar{a}} \frac{1}{\nu_{ijs}} dV$$

$$= \frac{e^{-\frac{-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}-\bar{a}}}{\sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq,t+1}}{\nu_{ijs}}-\bar{a}}} \int_{-\infty}^{\infty} e^{\sum_{klq} -e^{-\frac{V-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq,t+1}}{\nu_{ijs}}-\bar{a}}} \sum_{klq} e^{-\frac{V-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq,t+1}}{\nu_{ijs}}-\bar{a}} \frac{1}{\nu_{ijs}} dV$$

$$= \frac{e^{-\frac{-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}-\bar{a}}}{\sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq,t+1}}{\nu_{ijs}}-\bar{a}}} \left[e^{\sum_{klq} -e^{-\frac{V-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq,t+1}}{\nu_{ijs}}-\bar{a}}} \right]_{-\infty}^{\infty}$$

$$= \frac{e^{-\frac{-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}-\bar{a}}}{\sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq,t+1}}{\nu_{ijs}}-\bar{a}}} \left[e^{\sum_{klq} -e^{-\frac{V-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq,t+1}}{\nu_{ijs}}-\bar{a}}} \right]_{-\infty}^{\infty}$$

$$= \frac{e^{-\frac{-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}-\bar{a}}}{\sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq,t+1}}{\nu_{ijs}}-\bar{a}}} [1-0]$$

$$= \frac{e^{-\frac{-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}-\bar{a}}}{\sum_{klq} e^{-\frac{-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq,t+1}}{\nu_{ijs}}-\bar{a}}}$$

$$= \frac{e^{\frac{\rho V_{ghr}^{c,t+1}-\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}}}{\sum_{klq} e^{\frac{\rho V_{klq}^{c,t+1}-\kappa_{ijs}^{klq,t+1}}{\nu_{ijs}}}}$$

$$= \frac{\left(e^{\rho V_{ghr}^{c,t+1}-\kappa_{ijs}^{ghr,t+1}}\right)^{\frac{1}{\nu_{ijs}}}}{\sum_{klq} \left(e^{\rho V_{klq}^{c,t+1}-\kappa_{ijs}^{klq,t+1}}\right)^{\frac{1}{\nu_{ijs}}}}$$

2.1.3 Conditional Utility

Notice that the part of expected utility from moving to any location ghr conditional on that location providing the highest utility is the same for all workers that are currently in ijs and equal to their overall expected utility. This is similar to the unconditional utility above, but for one location and with weights divided by the chance of picking this location.

$$\frac{\int_{-\infty}^{\infty} V \Pr\left[\rho V_{klq}^{c,t+1} - \kappa_{ijs}^{klq,t+1} + \nu_{ijs} a_{klq}^{t+1} \leq V | \forall klq \neq ghr\right] \Pr\left[\rho V_{ghr}^{c,t+1} - \kappa_{ijs}^{ghr,t+1} + \nu_{ijs} a_{ghr}^{t+1} = V\right] dV}{\frac{\left(e^{\rho V_{ghr}^{c,t+1}-\kappa_{ijs}^{ghr,t+1}}\right)^{\frac{1}{\nu_{ijs}}}}{\sum_{klq}\left(e^{\rho V_{klq}^{c,t+1}-\kappa_{ijs}^{klq,t+1}}\right)^{\frac{1}{\nu_{ijs}}}}}$$

(as above for the integral)

$$= \frac{\sum_{klq}\left(e^{\rho V_{klq}^{c,t+1}-\kappa_{ijs}^{klq,t+1}}\right)^{\frac{1}{\nu_{ijs}}}}{\left(e^{\rho V_{ghr}^{c,t+1}-\kappa_{ijs}^{ghr,t+1}}\right)^{\frac{1}{\nu_{ijs}}}}\int_{-\infty}^{\infty} Ve^{-x}e^{-\frac{V-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}-\bar{a}}\frac{1}{\nu_{ijs}}dV$$

$$= \frac{\sum_{klq}\left(e^{\rho V_{klq}^{c,t+1}-\kappa_{ijs}^{klq,t+1}}\right)^{\frac{1}{\nu_{ijs}}}}{\left(e^{\rho V_{ghr}^{c,t+1}-\kappa_{ijs}^{ghr,t+1}}\right)^{\frac{1}{\nu_{ijs}}}}\int_{-\infty}^{\infty} Ve^{-x}e^{-\frac{V}{\nu_{ijs}}-\frac{-\rho V_{ghr}^{c,t+1}+\kappa_{ijs}^{ghr,t+1}}{\nu_{ijs}}-\bar{a}}\frac{1}{\nu_{ijs}}dV$$

$$= \int_{-\infty}^{\infty} Ve^{-x}\left(\sum_{klq} e^{-\frac{V-\rho V_{klq}^{c,t+1}+\kappa_{ijs}^{klq,t+1}}{\nu_{ijs}}-\bar{a}}\right)\frac{1}{\nu_{ijs}}dV$$

(as above)

$$= v_{ijs}\log\sum_{klq}\left(e^{\rho V_{klq}^{c,t+1}-\kappa_{ijs}^{klq,t+1}}\right)^{\frac{1}{\nu_{ijs}}}$$

3 Data

3.1 Basic Datasets and Indicators

The main data used for the current study is municipality level data taken from official statistical sources and was accquired from by Statistics Austria. In detail the data include the following indicators:

- Population: These data provide the number of inhabitants in each municipality on an annual basis for the years 2011 to 2021. To account for the repeated changes in administrative borders of municipalities, they have been harmonised to the municipality systematic of 2022 (Gemeindesystematik, 2022) by statistics Austria. In addition the data provide a disagregation by broad age categories (under 15, 15 to 64 and 65 or older) and by country of birth (with the categories being Austria, EU 15 countries[2], and EU 13 countries[3] and third countries). For those aged 15 or older it also provides a break down by educational attainment (compulsory education, upper secondary education and tertiary education) and labour market status according to ILO definitions (with the categories employed, unemployed, and out of the labour force). The employment status is further disagregated into active employment and temporary absence[4]. The out of labour force status is further disagregated into persons under 15, students (over the age of 15), persons in retirement and a category referred to as others).

[2]These are the countries that joined the European Union (EU) before 2004. Since data ranges back to pre-Brexit times the EU15 category also includes persons born in the United Kingdom in all data.

[3]These are the countries that joined the EU after 2004 including Croatia that joined in 2013

[4]This category includes persons on maternity leave and persons with temporary absence due to health reasons

- Employment at NACE 1 digit level: these data contain both the employed residing in a municipality as well as the employed working in a municipality (with the difference being net out-commuting) broken down by NACE 1 digit industries for the years 2011 to 2022.

- Place to place commuting data: This provides place to place commuting flows at a municipality level for all employed with their main residence in Austria for the years 2011 to 2022. As the data focus on Austrian residents, cross-border out-commuting (i.e. to other countries) is also reported, although the country of destination is not included. Cross-border in-commuting (i.e. from abroad) is, however, not reported as it involves residents of foreign countries.

  In addition the data provide a break down of commuters by NACE 1 digit industry and by a categorisation of the country of birth and educational attainment levels using the same categories as population respectively employment data.

- Internal place to place migration data: This provides municipality level place to place migrationfor the years 2002 to 2022 again broken down by crude age group and country group of birth. These data, however, lack information as to the labour market status of the migrant, because this data is not collected in the Austrian residence register.

- External Migration data: This provides municipality level out and in migration data for the years 2002 to 2022 again broken down by by crude age group and country group of birth again following the same categories as employment and population data,

3.2 Sources and Defintions

The source for the population, employment and commuting data is the harmonized employment statistics of Austria (Abgestimmte Erwerbsstatistik). This data source (provided and processed by Statistics Austria) integrates all available administrative data and statistical registers into a comprehensive body of employment statistics data at an annual frequency and is provided on a number of different geographic scales, including the municipality level. To comply with confidentiality limits, the data are statistically swapped for cells providing less than three observations.

The definitions used in compiling the data follow international definitions. Thus educational definitions follow ISCED definitions (with ISCED level 1 or 2 defining compulsory education ISCED 3 and 4 secondary education and levels from ISCED 5 upward tertiary education), labour market status definitions follow the ILO definitions and industry classifications are provided according to the NACE systematic. Details on the methodologies used in compiling this data are provided in STAT (2006)

The source of the internal and external migration data are the Austrian migration statistics (Wanderungsstatistik). These are based on registry data from the register of residence[5] and record all changes of location within Austria as well to and from Austria, associated with a change of main residence according to Austrian residence registration laws. According to

[5] Registration of residence and resident changes is compulsory in Austria, and is also associated with access to certain municipal services e.g. Kindergartens.

these laws migrants within Austria as well as from abroad must register for a permanent residence if their duration of stay exceeds 90 days (and emigrants must de-register their residence if they move their residence abroad for more than 90 days). Details on the methodologies used in compiling this data are provided in STAT (2002)

3.3 Wage Data

Next to these official data sources some indicators used for modelling purposes were imputed from other data sources. This applies in particular to wage data. This is imputed from individual level data from the Austrian Social Security Data set (ASSD). This is a widely used data set in Austrian labour market research (see Schoeberl (2004) for a description and Card u. a. (2007) and Huber u. a. (2017) for applications) originating from the compulsory social security system in Austria. It contains a daily calender of all employment relationships in Austria incuding their wages (up to the social security maximum) and originates from the compulsory social security system in Austria. From this data, to be consistent with other data sources, we calculated annual average wages for NACE1 digit industries at the level of Austrian districts (which is the smallest possible level of regional dis-aggregation) available for this data) in 2011.[6] To impute municipality level data we therefore assumed that wages within an NACE1 digit industry do not differ among the municipalities of a district.

Furthermore since this data provides wages at the place of residence of the individuals, wages at the place of work were imputed by assuming that wages of commuters across Austrian district borders do not differ from those of non commuters and using place to place commuting data to impute wages at the place at work. This was done by noting that under these assumptions the average wages (w_j^n) in a specific NACE1 digit industry (indexed by n) and the place of work (indexed by j) are given by $w_j^n = \frac{\sum_i w_i^n N_{ij}^n}{\sum_i N_{ij}^n}$, where w_i^n is the average wage in NACE industry n at the district of residence i and N_{ij}^n is the number of commuters from district i to district j.

In detail here we use follow the following algorithm in calculating wages at residence. In a first step from the commuting matrices provided by Statistics Austria for each industry and year we extract the number of workers working in a particular regions by their place of residence. In a second step we link the average wages (as measured in the ASSD) in the industry and at their place of work to these data. Finally in a third step we aggregate up this data to calculate the average wages at the place of residence according to the equation above.

3.4 Construction of Input-Output Matrices

Furthermore to create the make-use table and regional trade matrix required for the model at the municipal level, the national input-output matrices are used as a starting point. These were regionalized using additional (regional) data sets. The data sets used for this are: the input-output table (IOT, national level), the national accounts (VGR, national level), the regional accounts(RGR, federal state level), the structural business statistics survey (LSE,federal state level), the register-based labour market statistics (AESt, municipal level),

[6] In total there are 95 such districts in Austria, while there are 2011 municipalities.

the regional income survey (federal state level), the consumption structures from the Tourism Satellite Account and the regional foreign trade statistics (AH, federal state level). The year 2019 is used as the base year for regionalization and the ÖNACE classification of economic sectors at 2-digit level is used as the sectoral classification.

Regionalization is divided into 5 steps:

- allocation of the required economic indicators to the 9 federal states
- regionalization of the 9 federal states to the municipal level
- regionalization of the final demand
- calculation of TlS, TTM and imports
- creation of the interregional trade matrix

3.4.1 Federal State level

Using the LSE and RGR, the value added (VA) is first brought to the federal state level - if data is subject to confidentiality or is not included in the LSE, the national values are distributed using the employment from the AESt.[7] A bi-proportional balancing algorithm (the RAS method is used here) ensures that the values match the IOT. Value added regionalized in this way forms the anchor and starting point for all other variables, as the most detailed regional information is available for this key figure.

The production (Q) is calculated at the federal state level using the ratio between value added to production (VA/Q) in the LSE and the regional VA just calculated. All other economic indicators are derived via the ratios to Q. Variables that are not available in the LSE (such as depreciation) are regionalized using a structural approach: This involves using the national ratios of the corresponding variables (in relation to Q) at ÖNACE 3-digit level, calculating the absolute values at federal state level using these ratios and the regional production, and finally summing them up at ÖNACE 2-digit level.

3.4.2 Municipal level

In order to bring the economic key indicators to the municipal level, the employment of the AESt is used. This involves relating all previous variables (at federal state level) to employment and thus calculating the corresponding variables at the municipal level. This yields the production (supply/make) and intermediate consumption (use) by municipality and sector. This is extended by the goods dimension using the IOT goods structure. This gives a municipality*sector*goods matrix that contains production and intermediate consumption (sectoral demand). The "technology" of a sector is the same in all municipalities of a federal state, but differs between the federal states at ÖNACE 2-digit level.

[7] Classified industries in the LSE: B05-07, B09-09, C19. Industries not included in the LSE: A01-03, O84-T97.

3.4.3 Final demand

The final demand consists of private and public consumption, consumption by non-profit institutions serving households (NPISH) as well as investments, exports, changes in inventories and net additions to valuables.

Public consumption and the consumption of NPISHs are distributed to the municipalities via the population shares, while exports, changes in inventories and net additions to valuables are distributed via production. The regional investments of the sectors have already been calculated as an economic indicator in the previous step.

Private consumption is calculated using the sum of the different types of income, which can be taken from the regional income survey: childcare allowance, family allowance, other allowances, emergency allowance, care allowance, unemployment benefit and pension income are distributed regionally via specific population shares, gross wages are allocated to the place of residence using commuter data and self-employed income is estimated via the average income in the respective sector. The types of income are then taxed accordingly and the resulting disposable income is adjusted to the federal state totals of the national accounts.

Regional consumption rates and disposable income are used to obtain national consumption per good (national principle), which is adjusted to the corresponding IOT values. To do this, domestic consumption abroad (according to the national accounts) is deducted and domestic tourism and consumption by foreigners in Austria are (re)distributed using overnight stays data - this involves the use of different consumption structures.

3.5 TlS, TTM and imports

The national shares are assumed for the taxes less subsidies (TLS) (i.e. for each consumer and each good, the TlS shares are identical in all municipalities). The same procedure is used for transport and trade margins (TTM): each consumer pays the same margins for each good in all municipalities; the demand for margin goods in each municipality is then the sum of the individual margins, which are then allocated to the margin goods trade (G45-G47) and transport (H49-H53). The distribution shares for each consumer are taken from the IOT. Furthermore, TTMs can be traded like any other good.

The import quotas from the IOT (per user and good) are used as the starting point for imports. These imports are additionally refined using the AH by shifting them between the federal states. IOT and AH are harmonized via a RAS, which also takes into account that no municipality-user-good triple has imports above the corresponding use.[8]

This data provides a complete supply and use table for 81 users (74 sectors + 7 final demand components), 74 goods and municipalities. The goods and sectors are then summed up to ÖNACE 1 digits.

3.5.1 Interregional trade matrix

Interregional trade is estimated separately for each good using a RAS. The starting values for this RAS are calculated based on the use: From which municipalities is the use of a

[8]Additional attempts to include the distance of the respective municipality to the border did not improve the result.

municipality served? A certain proportion of each good is traded within its own municipality, the 5 nearest municipalities, the district capital, the provincial capital and the Austrian capital Vienna. The remaining share is distributed via a gravity matrix according to the formula: $\frac{supply \cdot use}{distance^{\gamma}}$ whereby different gravity parameters (γ) are used for different goods. (It is therefore assumed that goods have different "catchment areas". The allocation is essentially based on plausibility considerations).

These initial values are adjusted to the boundary values (the regional supply + imports on the one hand and the regional use on the other) using a RAS. Foreign trade is kept exogenous, which means that the original imports and exports are retained. However, it should be noted that re-exports are not counted twice in the RAS, as they appear in both variables.

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