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Use of non-traditional data sources to nowcast migration trends through Artificial Intelligence technologies.

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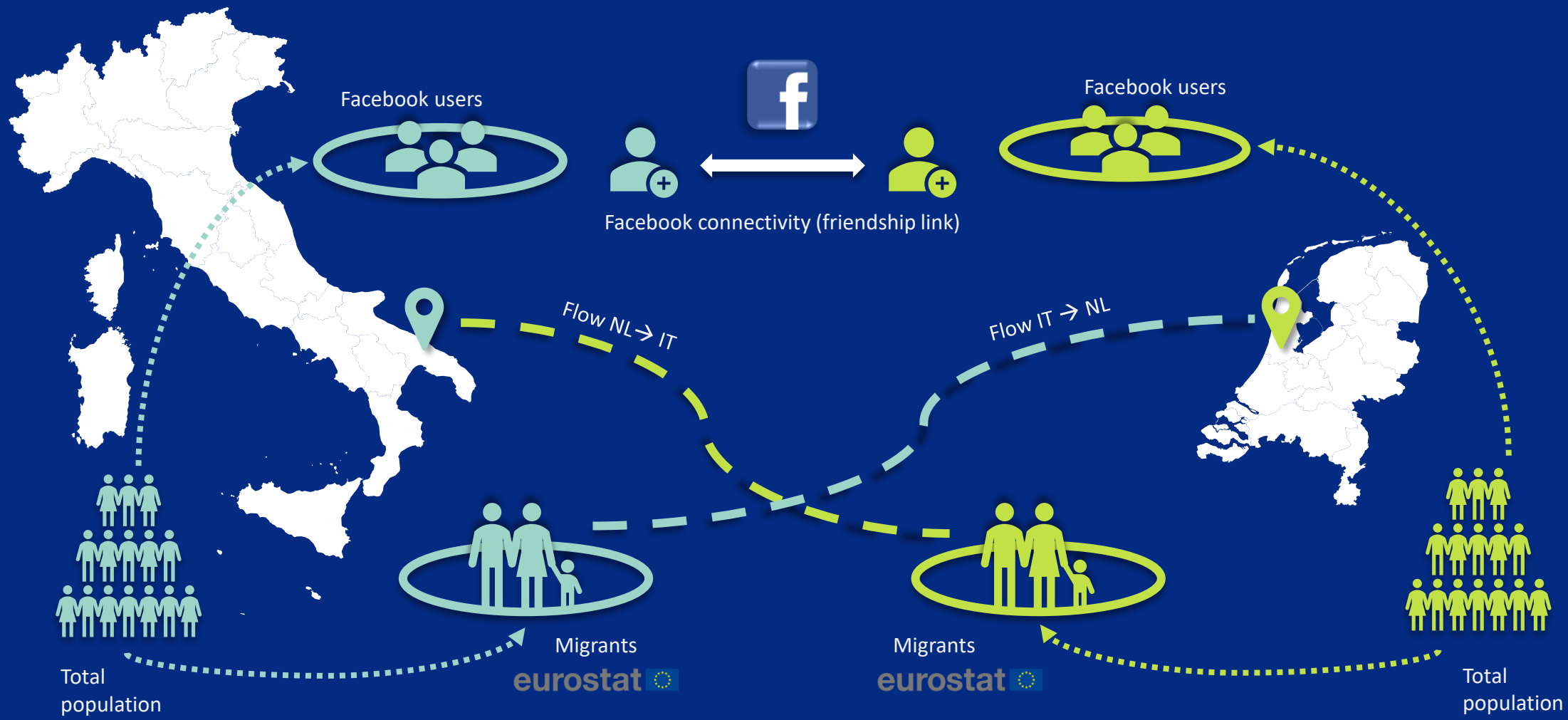
Session 1a: "How do we measure migration? Methods and advancements".
"Measuring Migration and Mobility" Conference | June 9th and 10th, 2022 |
Nuffield College, University of Oxford, Oxford, GB.

Nowcasting flows with Facebook Social Connectedness

Italy

The Netherlands



Step 1: data

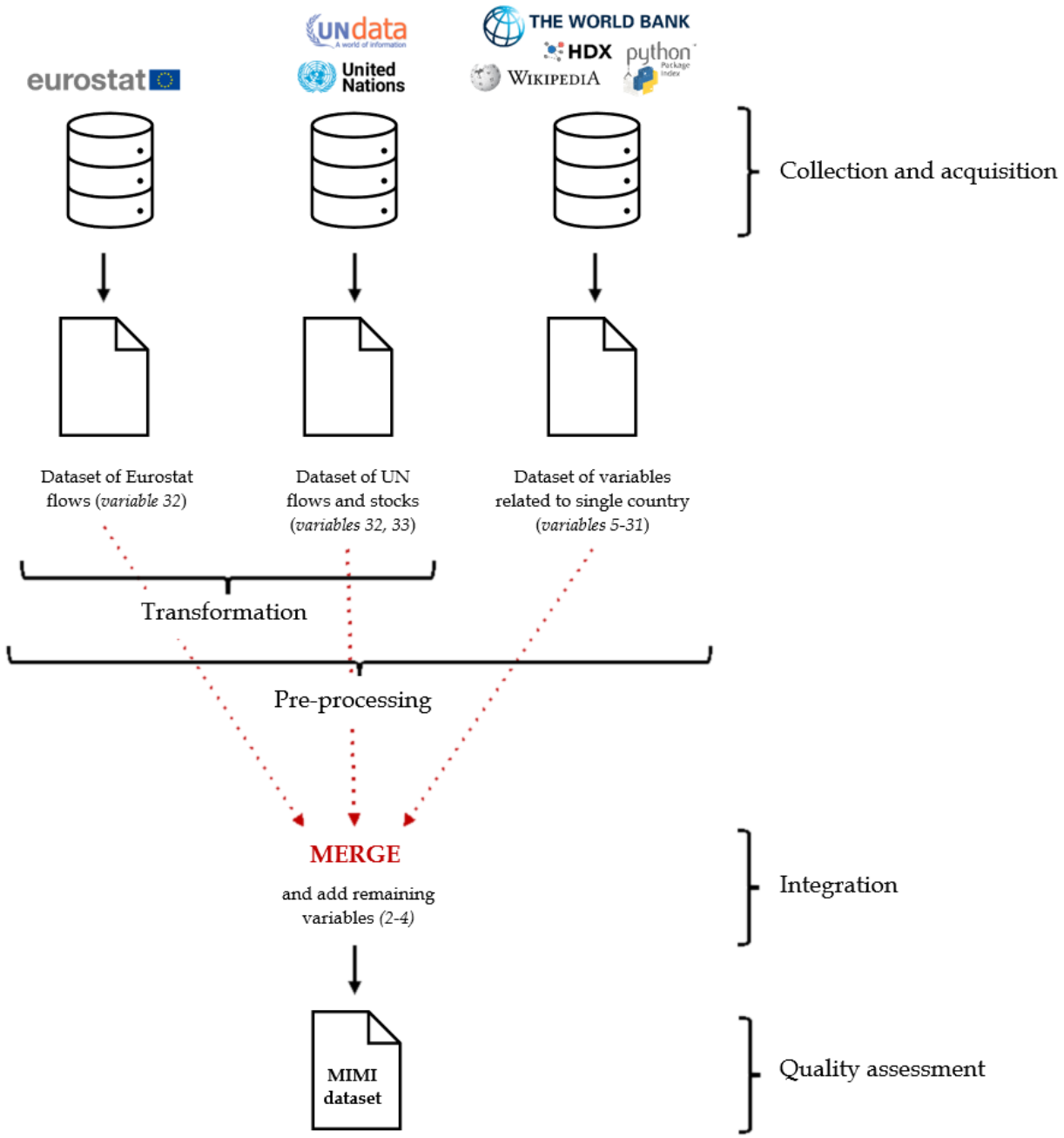
Starting point: MIMI dataset

Multi-aspect Integrated Migration Indicators dataset (CC BY 4.0). Publicly available at [10.5281/zenodo.6493325](https://doi.org/10.5281/zenodo.6493325)

- Non-trivial integration of scattered and heterogeneous data.
- Multidisciplinary variables and original indicators (economic, demographic, cultural and geographic), including Social Network Data.
- Demographers, sociologists, economists and researchers could explore and investigate trends.
- Possibility to develop complex models based on MIMI data.

Related papers

- Goglia, D. (2022) "Multi-aspect Integrated Migration Indicators (MIMI) dataset v2.0", Zenodo, [10.5281/zenodo.6493325](https://doi.org/10.5281/zenodo.6493325).
- Goglia, D., Pollacci, L., Sirbu, A. (2022) "Dataset of Multi-aspect Integrated Migration Indicators", ArXiv pre-print, https://arxiv.org/abs/2204.14223



Step 2: indices

Facebook connectivity & cross-border human mobility

Hypothesis: Facebook strength of connectivity between two countries is related to the bilateral contribution of migration flows.
We built a new indicator (BMI) to nowcast migration flows based on Facebook SCI.

Facebook Social Connectedness Index (SCI)

$$SCI_{i,j} = \frac{FB\_Connections_{i,j}}{FB\_Users_i * FB\_Users_j}$$

- **Non-traditional** variable within the context of migration studies, included in MIMI for 2020 and 2021 connectivity.
- Provided by "Data for Good at Meta (previously Facebook)" on Humanitarian Data Exchange.
- Measures the **relative probability** that two individuals across two locations i and j are friends with each other on Facebook.
- Could be employed as a proxy of social connections across borders, to be studied as a **possible driver of migration**.
- **Symmetric** structure by definition of "friendship" concept.

Bidirectional Migration Index (BMI)

$$BMI_{i,j} = \frac{Flow_{i\to j}(t) + Flow_{j\to i}(t)}{Pop_i(t) * Pop_j(t)}$$

- i and j represent countries (NUT0 level).
- t is the **reference year**.
- Sum of **direct** and **inverse** contributions → **symmetric** function considering the sharing of both flows.
- Strong **correlation** with SCI for flows provided by Eurostat statistics.
- Can be computed also by sex and by age group.

For couples of countries with inverse flow not available: **Unidirectional Migration Index** (asymmetric – directed – version of BMI).

$$UMI_{i,j} = \frac{Flow_{i,j}}{Pop_i * Pop_j}$$

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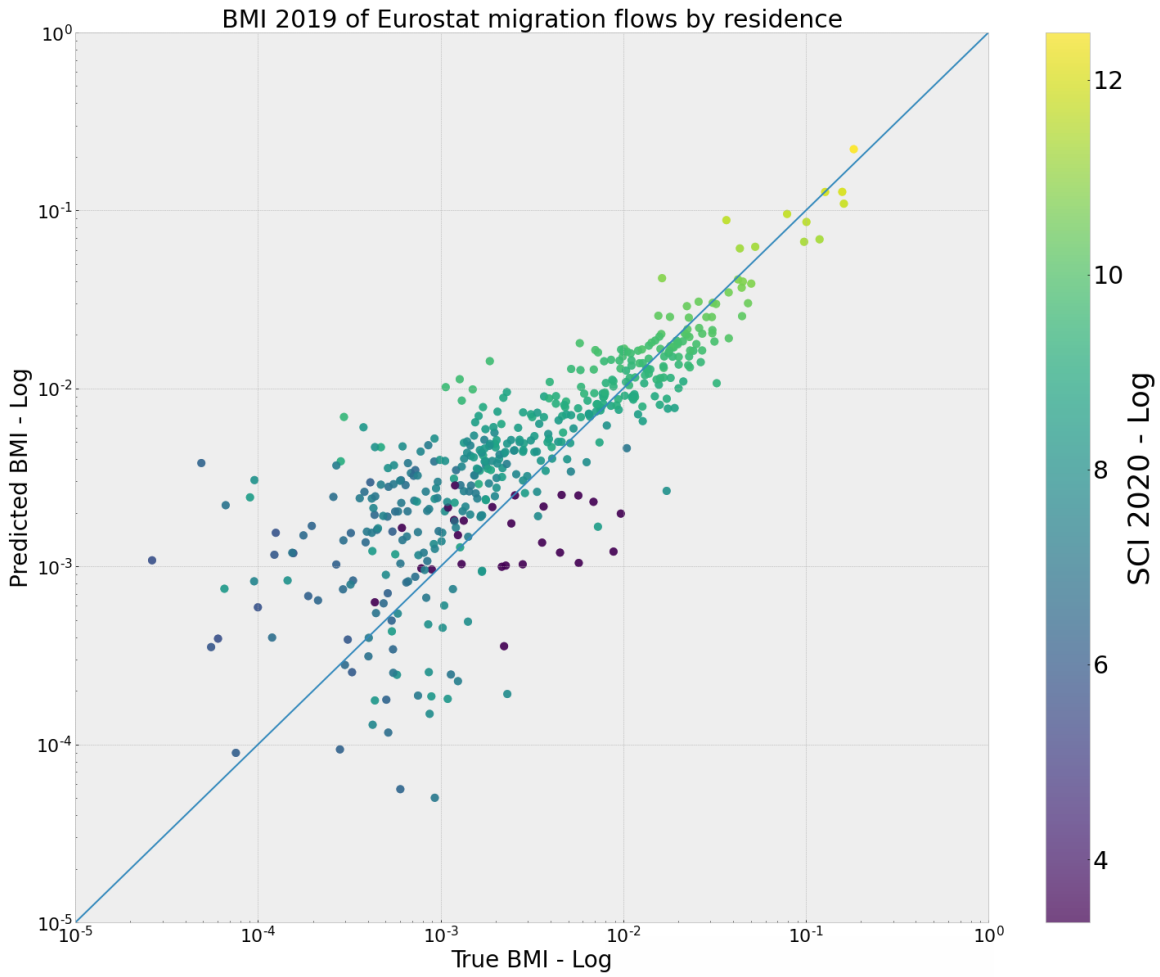
Step 3: fit

Linear Regression

Analysis of migration drivers

Model: Linear regression (Ordinary Least Squares model).
Task: simple fit to determine which variables are relevant and to prove the importance of SCI on BMI prediction.
Aim: feature selection for further neural models.

BMI 2019 of EUROSTAT migration flows by residence: true value VS linear regression predictions (best fit, model with $R^2 = 0.88$). Each data point in the plot represents a couple of countries.



Result

- Facebook strength of connectivity between two countries is strongly positively related to the amount of migration flows they share.
- Higher connectivity, more accurate migration prediction.

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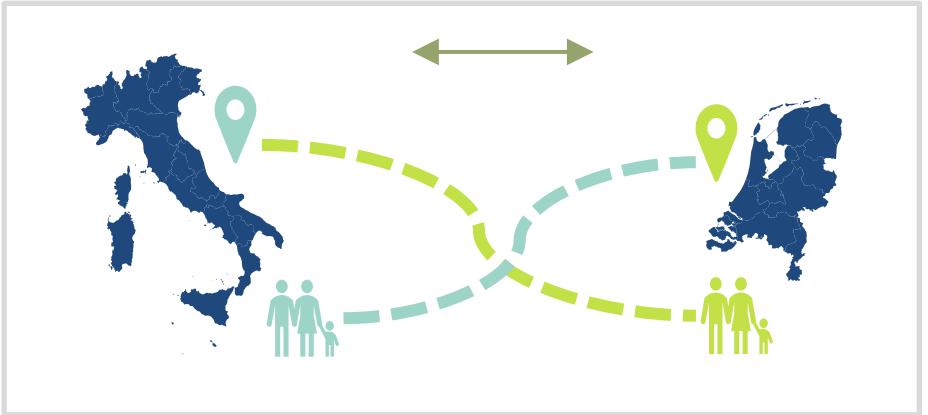
Results of OLS Backward Elimination Stepwise Linear Regression (I)

Bidirectional Migration Index

	By citizenship (148 couples, 14 countries)				By residence (1114 couples, 63 countries)			
Y	ESTAT BMI 2019 cit, without sci 2020		ESTAT BMI 2019 cit, with sci 2020		ESTAT BMI 2019 res, without sci 2020		ESTAT BMI 2019 res, with sci 2020	
Model n.	1	11	1	6	1	10	1	11
Feature	coef, P>|t|	coef, P>|t|	coef, P>|t|	coef, P>|t|	coef, P>|t|	coef, P>|t|	coef, P>|t|	coef, P>|t|
Intercept	-0.0005		0.0409 ***	0.0412 ***	0.0187 ***	0.0210 ***	0.1079 ***	0.1075 ***
sci_2020			0.0438 ***	0.0438 ***			0.1090 ***	0.1092 ***
geodesic_distance_km	-0.0161 **	-0.0114 ***	-0.0023	-0.0021	-0.0025		9.253e-05	
gdp_diff_2018	0.0074 **	0.0064 **	0.0032 ***	0.0033 ***	0.0040 ***	0.0039 ***	0.0018 ***	0.0016 ***
gdp_mean_2018	-0.0091 *	-0.0074 **	-0.0117 ***	-0.0116 ***	0.0058 ***	0.0055 ***	0.0005	
neighbours	0.0075 **	0.0081 ***	-0.0021 *	-0.0020 **	0.0138 ***	0.0140 ***	-0.0011	-0.0012 *
share_rel	0.0078 ***	0.0070 ***	0.0014	0.0013	0.0006		-0.0005 *	-0.0005 *
share_lang	-0.0024		-0.0013 *	-0.0014 **	0.0020 ***	0.0020 ***	0.0004	0.0004
PDI_diff	-0.0038	-0.0034	0.0020	0.0020	-0.0025 *	-0.0026 *	-0.0006	
IDV_diff	-0.0067 **	-0.0065 **	-0.0021 *	-0.0021 *	-0.0012		-0.0017 ***	-0.0017 ***
UAI_diff	0.0014		-0.0033 *	-0.0033 *	0.0003		0.0006	
MAS_diff	-0.0103 ***	-0.0088 ***	-0.0021 *	-0.0021 *	-0.0051 ***	-0.0050 ***	-0.0017 ***	-0.0018 ***
fb_users_diff	-0.0018		-0.0023 *	-0.0024 ***	0.0066	0.0068	-0.0007	
fb_users_perc_diff	0.0025		0.0043 ***	0.0044 ***	-0.0006		-8.071e-05	
fb_users_perc_mean	0.0028	0.0049	0.0025	0.0026 *	0.0054 ***	0.0055 ***	0.0044 ***	0.0047 ***
fb_users_mean	-0.0134 **	-0.0145 ***	-0.0005		-0.0114 *	-0.0112 *	-0.0010	-0.0016 **
area_diff	-0.0019		0.0002		-0.0029		0.0012	
area_mean	0.0036		0.0004		0.0034		-0.0011	
share_cont	0.0005				0.0047 ***	0.0063 ***	0.0010	0.0011 ***
R2 (centered)	0.574	0.560	0.949	**0.949**	0.363	0.361	0.880	**0.880**
AIC	-846.3	-855.7	-1158.	**-1164.**	-6321.	-6332.	-8179.	**-8191.**
BIC	-795.4	-825.7	-1104.	**-1119.**	-6231.	-6276.	-8084.	**-8136.**

Previous plot



- Dependent variable (y) is BMI → Symmetric indicator → Independent variables are undirected.
- Four different models: flows by citizenship / residence, including / not including SCI.
- Substantial improvement in models with SCI.
- SCI positively and strongly relevant feature.

```
  * p-value < 0.05
 ** p-value < 0.01
*** p-value < 0.001
```

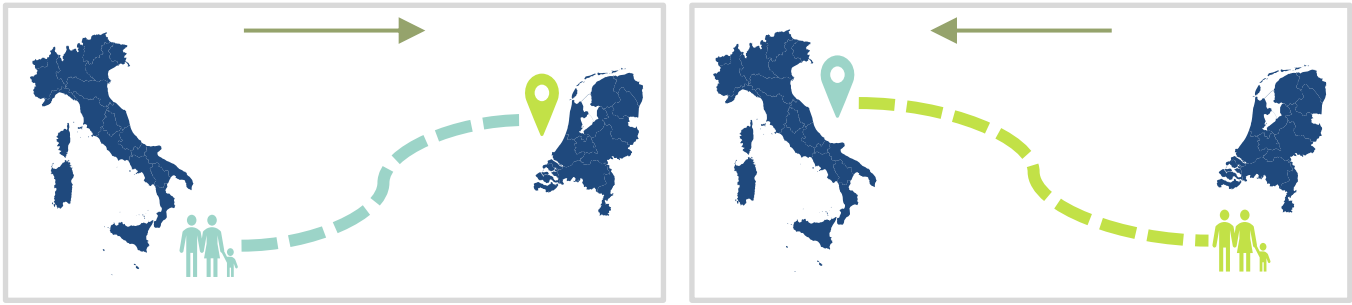
Results of OLS Backward Elimination Stepwise Linear Regression (II)

Unidirectional Migration Index

	By citizenship (748 couples, 200+ countries)			
y	ESTAT UMI 2019 cit, without sci 2020		ESTAT UMI 2019 cit, with sci 2020	
Model n.	1	20	1	18
Feature	coef, P>|t|	coef, P>|t|	coef, P>|t|	coef, P>|t|
intercept	-0.0027		0.2080 ***	0.2072 ***
sci_2020			0.2024 ***	0.2024 ***
origin_PDI	-0.0056		-0.0009	
destination_PDI	0.0012		0.0036*	
origin_IDV	-0.0053		-0.0011	
destination_IDV	-0.0021		-0.0051	
origin_UAI	-0.0033		-0.0017	
destination_UAI	-0.0033		-0.0049 *	-0.0023 *
origin_MAS	-0.0035	-0.0053	-0.0005	
destination_MAS	0.0022		-0.0002	
origin_area	0.0002		0.0004	
destination_area	-0.0017		-0.0040 *	-0.0020 *
origin_fb_users	-0.0012		-0.0012	
destination_fb_users	-0.0038	-0.0071 ***	0.0036	
origin_fb_users_perc	0.0054	0.0043	0.0039 *	0.0025
destination_fb_users_perc	0.0012		0.0010	
geodesic_distance_km	-0.0114 *	-0.0111 ***	-0.0025	-0.0038 **
origin_gdp_2018	0.0007		-0.0015	
destination_gdp_2018	0.0026		0.0026	
gdp_diff_2018	-0.0002		-0.0018	
neighbours	-0.0049		0.0042 **	0.0040 **
share_cont	0.0010		0.0017	
share_rel	0.0031	0.0033 **	0.0009	0.0013 *
share_lang	0.0084 ***	0.0077 ***	0.0010	0.0012
R2 (centered)	0.115	0.103	0.780	**0.777**
AIC	-3043.	-3065.	-4081.	**-4100.**
BIC	-2941.	-3037.	-3975.	**-4059.**

GDP proxy

GDP proxy



- Dependent variable (y) is UMI → Asymmetric indicator → Direction preserved in independent variables (distinction kept between origin and destination).
- Strong improvement in the model with SCI.
- SCI is again a very relevant feature, with positive coefficient.
- Other relevant features are different w.r.t. the previous model.
- GDP does not appear but remains significant since approximated by the presence of «country area» and «FB users» variables.

```
 * p-value < 0.05
** p-value < 0.01
*** p-value < 0.001
```

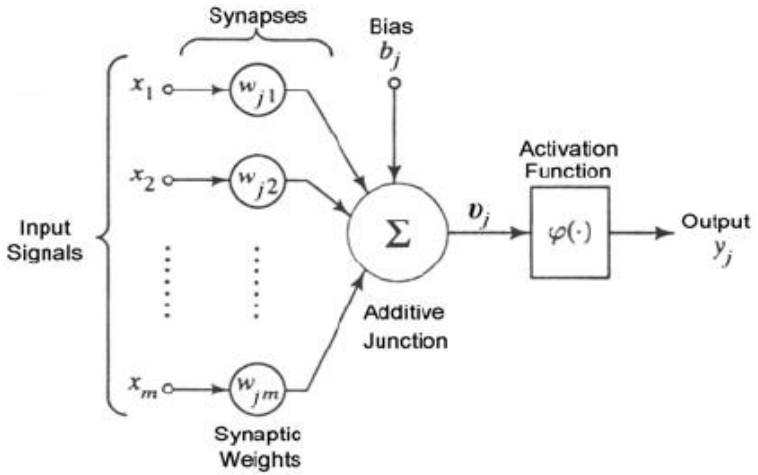
Next step: Deep Learning model

New tasks: migration **nowcasting** and **prediction** with deep Artificial Neural Networks (e.g., Feed Forward Multilayer Perceptron).
Input layer = relevant features selected by regression model + migration time series data.

Two possible analyses:

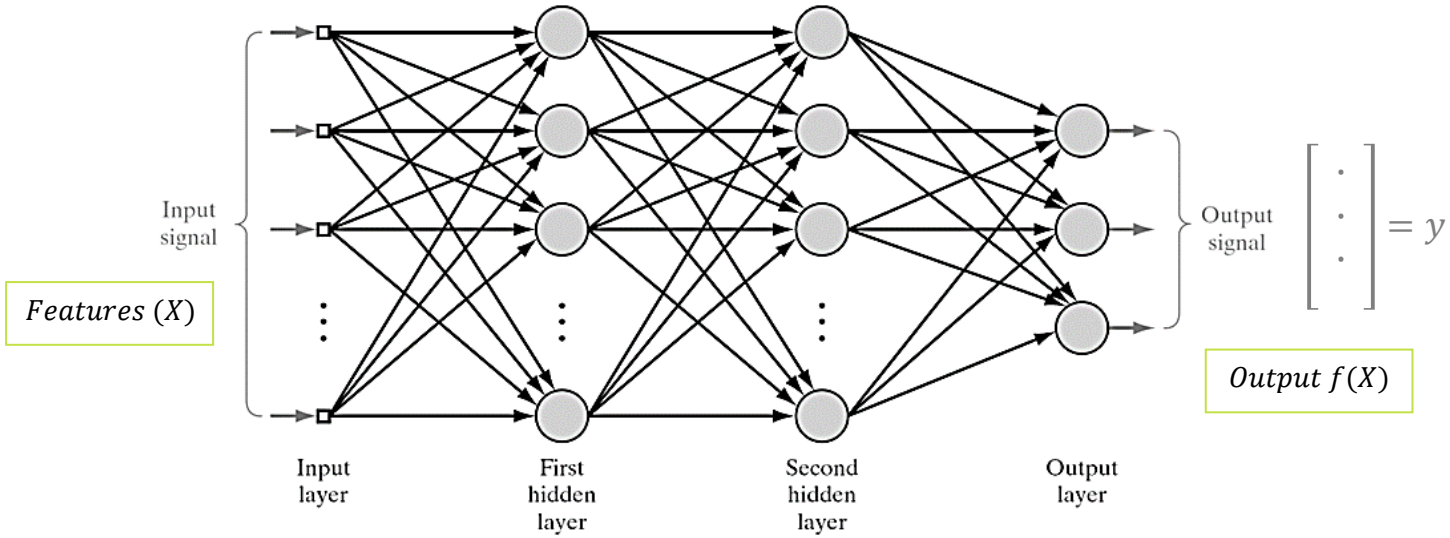
- Exploit a time window of past flows to predict future migration.
- Train-test split on couples of countries to predict migration flows only for some pairs.

Scheduled: experiments on MLP and Random Forest models and evaluation on better performance outcomes.



$$y_j = \varphi(\sum_{k=1}^{m} w_{jk} x_k + b_j)$$

Artificial neuron



Standard structure of MLP

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AI4MIG

Want more? Scan me!

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