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ANALYSIS OF VULNERABLE MIGRATION IN EUROPEAN UNION COUNTRIES USING A GRAVITY SPATIAL MODEL: THE SYRIAN CASE

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Abstract

Migration represents a complex phenomenon that, when associated with vulnerability, becomes a theme of particular importance in the current global context.

The refugees' crisis had a direct influence on permanent migrants. The COVID-19 pandemic had an impact on short-term migration, increasing the quantity of short-term migrants while decreasing the number of long-term displacement. In this context, the data presented in our study are from 2019, a year in which the mobility constraints resulting from the pandemics have not yet had an impact on migratory flows.

All European Union countries were covered, except Cyprus, where data was unavailable. Our study uses a gravity model of migration Syrian migrant. Through our analysis, we aimed to capture the determinants of migration flows from Syria to EU countries. It also aims to capture a range of spatial effects that may have an impact on the factors influencing the migration flows of Syrian migrants into the European Union countries. The results showed significant influences on Syrian migration flow to European Union countries, distance being a decisive factor in the decision to migrate.

Keywords: immigration, spatial regression, gravity model, vulnerable migration
JEL Classification: C21; F22; H56; O15

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1. Introduction

Immigration has recently known an increasing interest among researchers and political actors (Kwiliski et al, 2022). The current political situation in some countries generated an important impact on European Union countries through one of the oldest social phenomenon: migration (Rossi, 2018; Egger and Pfaffermayr, 2024). People's reasons for migrating, known as push factors, have always been diverse, heterogeneous, and complex, depending on the social, political, climatic, or economic context of the countries or territories they live in. Among the many push factors, war or social conflicts in a country drive people to seek more peaceful places (Urbański, 2022). In this paper we consider one important migrant group which has had and continues to have a decisive impact on the socio-economic situation in EU countries, namely Syrian migrants (Mallett and Hagen-Zanker, 2018; Valenta et al, 2020). Syria is a

conflict-affected country that have led people to decide to leave their country of origin for European Union countries (Schwartz, 2018; Ash and Obradovich, 2020; Martín, 2022; Brücker, 2022). Taking these aspects into account, we can say that Syrian migrants belong to the category of vulnerable migrants (La Spina, 2021).

Another important aspect to note is the COVID-19 pandemic, which has left its mark on temporary migration, leading to an increase in the number of temporary migrants but a decrease in long-term displacement (Permitez-Agan et al, 2020). In this context our article focuses on data from 2019, a year in which migration flows have not yet been affected by mobility restrictions during the pandemics (Chakraborty and Maity, 2020). The independent variables were selected for year 2019 because we aimed to capture a representative snapshot of the EU member states before the pandemic's impact, excluding the distortion caused by the pandemic on their economies.

We included almost all EU countries except Cyprus due to the data unavailability. Our paper focuses on applying a gravity model of migration, and at the same time, it aims to capture a series of spatial effects that could influence the determinants of Syrian migrant flows to the EU. The gravity model traditionally used in trade and transportation can be adapted to migration studies. Our main objective in doing this analysis is to identify the factors that impact the migratory flows from Syria to European Union nations. In this process, we examined the presence of spatial dependencies to understand how the movement of migrants from Syria to EU countries is influenced by spatial contiguity.

To provide a comprehensive understanding of the migration flows of Syrian refugees to EU countries, this paper is organized as follows: the underlying theories and prior research on gravity models and spatial dependencies in migration studies are examined in the Literature Review. The methodology, including the gravity model, spatial econometric methods, and data specifications, are described in the Method and Data section. The results are examined and reported in the Results and Discussion section, with particular attention paid to the effects of economic and spatial dependencies, but also including the study's limitations. The final part, Conclusions, highlights the most important findings presenting the main novel aspect of the analysis, and recommends topics for additional research.

2. Literature review

There have been numerous studies documenting the dynamics of the socio-political situation of the Syrian Civil War (Ford, 2019; Baltes, 2016) and its impact on migration. This literature review will explore current Syrian migration patterns after the 2015 Syrian Refugee Crisis, while studying any underlying determinants and also while excluding the influence of the COVID-19 Pandemic. EUROSTAT (2023) offers us some insight into the Syrian Migration Crisis. From 2014 to 2023 the European Union registered over 6.5 million first time asylum seekers, 21% of those being of Syrian origins. We can see that the number of Syrian refugees hit its peak in 2015 with 360 thousand first time applicants, however the numbers have been steadily increasing in recent years, ever since 2020. Considering these aspects, it is reasonable to classify migrants from Syria as vulnerable (La Spina, 2021).

Gilodi et al. (2022) define vulnerability as a versatile condition that depends on the specific context of each situation, emphasizing that it cannot be understood or applied universally. In

academic literature, policy-making, humanitarian debates, and everyday discussions on migration and asylum, vulnerability is often treated as a self-explanatory phenomenon. However, Gilodi et al. (2022) highlight the lack of a common and systematic understanding of this concept, drawing attention to the moral and political meanings attributed to it, which can have unintended or intentional negative consequences for migrants deemed vulnerable.

Paul (2013) offers a recurring definition of vulnerability as "an internal risk factor of the subject or a system exposed to danger, corresponding to its intrinsic tendency to be affected or susceptible to harm" (p. 1).

From a definitional perspective, vulnerable migration is approached differently across various sources and contexts. Essentially, it involves a mix of factors such as socio-economic vulnerabilities and lack of access to resources. The defining aspects of vulnerable migration are varied and complex, reflecting the challenges faced by individuals or groups in situations like homelessness, difficulties in finding employment, war, or integration into host countries.

The literature review regarding Syrian refugees gives us an understanding into which factors determine the decision to emigrate to a certain country or region. İnce (2019) emphasizes in their paper that, the Province of Şanlıurfa, a region fostering the biggest border with Syria, also hosts the highest number of Syrian refugees. This region seems particularly favourable for Syrian refugees because of the similar ethnic, cultural and religious background of the locals, bringing about a much easier immigration process (İnce, 2019).

Another paper, utilizing a gravity model for researching forced global migration has concluded that, while the hypothesis that geographic distance and sharing a common border between origin and destination countries proved significant (Echevarria et. Gardeazabal, 2016), the level of civil liberties in the destination country that the refugees are entitled to played a much more significant role.

Luby (2018), while also using a gravity model of migration, has found that the main factor which influences migrant's decision for their destination country is the strength of the economy (i.e total GDP). The size of the population of the host country also has an important influence of the decision to emigrate, however the distance between the country of origin and the destination country did not play a significant role, thus a distance dependent gravity model could not be used (Luby, 2018).

Simpson (2022), studies in their paper the different push and pull factors for migration, keeping into account economic and demographic factors. Their research suggests that, in general, pull factors consist of an already existing network of migrants from the same country of origin, high rates of government transfers (e.g. unemployment insurance and welfare), a strong foreign currency and low unemployment rates. Moreover, push factors are determined by high taxes, a strong home currency, high unemployment rates, high travel costs (dependent on distance and fees for visas and resident permits) and tight immigration policies.

Research indicates that there are significant differences in how various groups of migrants are received by the destination country. For example, Drewski and Gerhards (2024) have contextualized the contrasting levels of support for Syrian migrants in Poland and Germany. While the German Government approached the Syrian migration crises from a humanitarian standpoint, differentiating very little between migrant groups, Poland has had a completely different approach. Friedman (2024) also confirms this, as in 2015, Poland deemed Syrian migrants unfit to enter their country, viewing them as security threats.

Another study, analysing Syrian migration using a survey, has found that there exists a statistically significant negative correlation between Syrians wanting to stay as long as possible in their host countries and a lack of support and policies for them (Jasko et al., 2024). Also, there exists a statistically significant correlation between the desire for refugees to return to their home country as soon as possible and ample support and welcoming policies.

3. Method and data

In this paper we used a Gravity Model applied to study vulnerable migration flows in European Union. According to Sharma et al (2023) the Gravity Model was first mentioned in 1962 but started to gain popularity after 1980. This model was developed using an analogy of the Issac Newton's universal law of gravitation, according to which any object in the universe attracts other objects with a force directly proportional to their mass and inversely proportional to their distance (Sharma et al, 2023). The following equation illustrates the universal law of gravitation:

$$F_{ij} = g\frac{M_i M_j}{D_{ij}^2} \quad (1)$$

(Mele and Baistrocchi, 2012; Sharma et al, 2023)

In which:

- $\boldsymbol{F_{ij}}$ represents the force of attraction between the two objects;
- $\boldsymbol{M_i}$ and $\boldsymbol{M_j}$ represent the masses of the two bodies;
- D_{ij}^2 represents the square distance between objects ***i*** and ***j***;
- ***g*** represents the gravity force.

Therefore, as stated by Mele and Baistrocchi (2012) and Sharma et al (2023), starting from Isaac Newton's universal law of gravitation, the gravity model illustrates bilateral trade between two countries, which is directly correlated to GDP and inversely proportional to the distance between them using the following equation:

$$F_{ij} = G\frac{Y_i^{\alpha} Y_j^{\beta}}{D_{ij}^{\delta}} \quad (2)$$

Where:

- $\boldsymbol{F_{ij}}$ represents the value of trade flows from the country of reference ***(i)*** to the country of destination ***(j)***;
- $\boldsymbol{Y_i}$ and $\boldsymbol{Y_j}$ represent the total economic mass of the exporting country ***(i)*** and the importing country ***(j)*** (measured using GDP or GDP per capita);
- $\boldsymbol{D_{ij}}$ represents the geographical distance between countries ***i*** and ***j***;
- $\boldsymbol{\alpha, \beta}$ and $\boldsymbol{\delta}$ represent the parameters of the equation;
- ***G*** represents a gravity constant.

The initial form of the gravity model was linearized by applying the logarithm transformation to simplify the econometric estimation, resulting the following linear regression model (Sharma et al, 2023; Egger and Pfaffermayr, 2024):

$$ln\ F_{ij} = ln\ G + \alpha\ ln\ Y_i + \beta\ ln\ Y_j - \delta\ ln\ D_{ij} + \varepsilon_{ij} \quad (3)$$

Where:

- **ln** G represents the intercept of the equation;
- α, β and δ represent the coefficients of the equation;
- ε_{ij} represents the error term, which illustrates a multi-linear regression.

The model presented in Equation (3) is considered a restricted version of the Gravity Model. Additional auxiliary variables can be included to extend the analysis based on the observed factors (Bikker, 1987).

Although space has been considered as component of the Gravity Model, using the distance between the reference country and the target countries and other components deemed relevant to trade volume (such as geographical contiguity) (Sharma et al, 2023), some interactions between variables can be improved using spatial dependence analysis methods. To include spatial dependencies in the model, the neighbourhood relationship between countries must first be established. For this, we used the queen contiguity matrix.

In this paper we focus on two types of spatial dependence: lag and error. In order to check the spatial dependence in the linear regression model we applied the contiguity tests available using GeoDa software: Lagrange Multiplier (LM) tests for error and lag and Robust LM for error and lag (Anselin et al, 2006). In this context, we will consider two types of spatial Gravity Models:

- The spatial lag gravity model (spatial dependence is included in the model through the spatial lag of the dependent variable).
- The spatial error gravity model (spatial dependence is included in autoregressive errors).

Most often, gravity regression models are used to model trade flows or exports from the reference country to the destination countries (Sharma et al, 2023), but gravity models can also be used to estimate migration (Vanderkamp, 1977; Ramos, 2016).

The data was primarily obtained from the statistical office of the European Union (EUROSTAT), with some variables from World Bank Open Data and UN Refugee Agency.

Table no. 1: The variables

Variable name	Variable abreviation	Description	Source
Number of Syrian Refugees	syr_ref	Dependent variable Definition: Number of people with Syrian citizenship who have fled war, violence, conflict or persecution and have crossed an international border to find safety in another country.	UN Refugee Agency
Distance from Syria	lndsyr	Independent variable Definition: Calculated by author as the distance between the geographical centre of Syria and the geographical centre of the country of reference.	Author's own work
Real GDP per Capita	Ln_gdp	Independent variable Definition: The ratio of real GDP to the average population of a specific year. GDP measures the value of total final output of goods and services produced by an economy within a certain period of time.	Eurostat

Variable name	Variable abreviation	Description	Source
Proportion of Urban Population	urb_pop	Independent variable Definition: The ratio between the urban population of a country and the total population.	WorldBank
Poverty Rate	PovR	Independent variable Definition: the share of people with an equivalised disposable income (after social transfer) below the at-risk-of-poverty threshold, which is set at 60 % of the national median equivalised disposable income after social transfers.	Eurostat
Corruption Perception Index	cpi	Independent variable Definition: A composite index that ranks countries based on how corrupt a country's public sector is perceived to be, with a score of 0 representing a very high level of corruption and a score of 100 representing a very clean country.	Eurostat
Proportion of Population over 65 years old	prop_65	Independent variable Definition: The ratio between the population ages 65 years old and over and the total population for a given year.	Eurostat
Unemployment Rate	unemp_r	Independent variable Definition: The unemployment rate represents unemployed persons as a percentage of the labour force based on International Labour Office (ILO) definition.	Eurostat
Infant Mortality Rate	inf_mort	Independent variable Definition: The ratio of the number of deaths of children under one year of age during the year to the number of live births in that year. The value is expressed per 1 000 live births.	Eurostat
Healthcare Expenditure	healt_xp	Independent variable Definition: Health care expenditure quantifies the economic resources dedicated to health functions, excluding capital investment.	Eurostat
Median Income	med_inc	Independent variable Definition: It is the income that divides the population of a country into two groups, half having an income above that amount, and half having an income below that amount.	Eurostat
Fertility rate	FertR	Independent variable Definition: The mean number of children that would be born alive to a woman during her lifetime if she were to survive and pass through her childbearing years conforming to the fertility rates by age of a given year.	Eurostat
Life Expectancy	life_exp	Independent variable Definition: The mean number of years that a new-born child can expect to live if subjected throughout his life to the current mortality conditions.	Eurostat

Source: Data processed by the authors according to the sources mentioned in the table

Our dataset includes almost all EU countries except Cyprus due to the lack of data. All the variables were selected for the year 2019 in order to assure that the results are up to date, while ignoring the impact of the COVID-19 pandemic on the economies of the destination countries and migratory flows. In Table no. 1 we presented all the variables employed together with a description.

4. Results and discussions

In this paper we considered as dependent variable the flow of Syrian migrants to EU countries. These migrants can be considered vulnerable due to the war conditions in their country (Spathopoulou et al, 2022). For a regression model to be considered a gravity model, it must meet a series of conditions: the dependent variable must be a flow variable (in our case, this will be the flow of Syrian migrants to EU countries), and the variables of gross domestic product and the distance between the reference country and the target countries must be statistically significant. We anticipate that, provided the conditions of the gravity regression model are met, the number of Syrian migrants will rise with an increase in gross domestic product and will decline as the geographical distance between the country of origin and the destination country increases.

Considering that our dataset contains 10 auxiliary variables in addition to the basic gravity model, this aspect led us to use a dimensionality reduction method. We applied principal component analysis, resulting in four principal components according to Kaiser Criterion and Eigenvalues (see Appendix 1) as follows:

Table no. 2: Principal Components (PCs) of the auxiliary variables

Principal Component	PC1	PC2	PC3	PC4
Variables included	Corruption Perception Index	Proportion of Population over 65 years old	Fertility rate	Poverty Rate
	Median Income	Unemployment Rate	Healthcare Expenditure	Infant Mortality Rate
	Life Expectancy			
	Proportion of Urban Population			
the % of total variance explained by each component	34.87%	18.51%	12.39%	11.45%

Source: Data processed by the authors using GeoDa

The first principal component observed in Table no. 2 is correlated directly with median income, life expectancy and the Corruption Perceptions Index, while being indirectly correlated with the proportion of the urban population. As such, we may consider a country with a high PC1 score to be more developed since it will be less corrupt, it will have a higher life expectancy and higher median income.

The second principal component is correlated indirectly with the proportion of the elderly population and with the unemployment rate. We will consider a low PC2 score to be indicative

of a stable environment for the occupied labour force given by the low unemployment rate and the smaller segment of the inactive population that workers need to support economically.

The third principal component is correlated directly with fertility rate and healthcare expenditure in a given country. A high PC3 score signifies demographic sustainability along with the capacity to ensure the health of the future population.

The last principal component is correlated directly with the poverty rate and the infant mortality rate. In essence, a high PC4 value is indicative of limited access to essential resources leading to increased poverty and infant mortality.

We estimated a gravity model for the Syrian migrants including the four principal components obtained from the dimensionality reduction of the 10 variables considered in the analysis.

Table no. 3: The Gravity Model results

Variable name	Coefficient	P-value
Constant	28.02	0.158
PC1	0.71	0.177
PC2	-0.50	0.056
PC3	0.69	0.018
PC4	0.99	0.002
LN(DISTANCE)	-3.89	0.022
LN(GDP)	1.07	0.509

Source: Results obtained by the authors using GeoDa

The gravity model of migration is confirmed only if we consider the sign of the gravitational variables: distance and GDP, but only the distance is statistically significant at 5% significance level. All principal components are statistically significant at 5% significance level, except PC1. These results suggest that, Syrian migrants prefer countries that have a stable working environment for the employed population, high fertility rates and substantial healthcare expenditures, indicating a capacity to care for current and future generations.

Table no. 4: Spatial dependence tests

Test	Result (p-value)
Moran's I (error)	0.1653 (*0.868*)
Lagrange Multiplier (lag)	0.875 (*0.349*)
Robust LM (lag)	3.4206 (*0.064*)
Lagrange Multiplier (error)	0.6857 (*0.407*)
Robust LM (error)	3.2304 (0.*072*)

Source: Results obtained by authors using GeoDa

The results of spatial dependence tests, show that spatial dependence in the error and lag at a significance level of 10%. By comparing the robust LM test for lag and error, we can say that the gravitational model exhibits spatial lag dependence. In the table below we will continue with a gravity model using the number of Syrian migrants and the dependent variable, incorporating the influence of a spatial lag.

Table no. 5: The Spatial LAG Gravity Model results

Variable name	Coefficient	P-value
Constant	27.81	0.107
W_LN(Syrian Migrants)	0.003	0.970
PC1	0.70	0.128
PC2	-0.50	0.017
PC3	0.69	0.004
PC4	0.99	0.000
LN(DISTANCE)	-3.88	0.004
LN(GDP)	1.08	0.438

Source: Results obtained by the authors using GeoDa

The spatial gravity model is confirmed for the Syrian migrants only if we consider the sign of the gravitational variables: distance and GDP, but only the distance remains significant. GDP generally reflects the economic well-being of a country (Islam and Clarke, 2002); however, since it is not statistically significant in the gravity model, we can consider that any EU country is economically more developed than Syria (Ülker et al, 2016; Lichtenheld and Schon, 2021). Therefore, GDP is not a decisive factor for the flow of Syrian migrants but the proximity of a country is an important factor. Comparing the results in Table no. 5 with the results in Table no. 3 of the gravity model without spatial dependence, we observe that the spatial gravity model brings an improvement in the statistical significance of the results. However, the spatial lag variable is not statistically significant. The significance and signs of the principal components remains the same as in Table no. 3, with the results suggesting that Syrian migrants favour countries with a stable working environment, high fertility rates, and substantial healthcare expenditures.

Our study highlights the gravitational effect of vulnerable migration toward EU countries. By focusing specifically on an important category of vulnerable migrants: Syrians, we can observe that the proximity of countries is a decisive factor for the flow of Syrian migrants from the reference countries to the target countries.

The main limitation of our study is the lack of data. For the analysis of the Syrian Case Study to be more robust, it is necessary to observe the variables over a longer period of time especially the number of Syrian migrants fleeing to each country. Another limitation is the applied method, which may include other types of spatial dependencies that could potentially capture the effects more accurately considering that the estimated spatial effects were not statistically significant and the spatial dependence tests confirmed their presence only for 10% significance level. Nevertheless, spatial dependence exists and has to be investigated further by carrying out more tests that verify this type of spatial model. The nature and degree of the spatial associations in the data may become clearer as a result of this further study.

5. Conclusions

To conclude, in this study, based on the theory of gravity model theory applied in migration, we investigated the impact of various economic factors on Syrian migratory movement. The aim of our study was to identify the key determinants of vulnerable Syrian migration, to assess whether the principles of the gravity model are applicable to the movements of Syrian refugees

and to explore additional factors influencing migration decisions to specific countries, such as spatial dependence. Our model meets the criteria of a gravitational model, having an inverse relationship between distance and the number of Syrian migrants, and a direct relationship with the GDP variable. The estimated gravity model is statistically significant when considering distance. The distance remains a key factor in selecting a destination country, while GDP does not play a significant role. This can be attributed to the fact that all EU member states have a significantly higher GDP than Syria, making GDP less impactful in their decision-making.

Healthcare expenditure is an important factor for Syrian refugees when choosing a destination. Also, Syrians prioritize a stable working environment, characterized by low unemployment rates and a smaller proportion of the elderly population.

Besides the fact that the analysis validates the gravity model, we can also observe the presence of spatial dependence, specifically in the spatial lag component. These findings highlight the importance of incorporating spatial dependence in similar studies to improve the accuracy and reliability of the results.

This article explores how the gravitational model can effectively analyse the flow of Syrian migrants, focusing on the various economic factors that affect their decisions to remain in specific EU countries. The main novelty of this study is that it includes the spatial dependence in the gravitational model of migration. Our results are offering valuable insights for both academic research and practical policymaking, even though they present certain limitation.

By focusing on economic opportunities and social support, EU countries can contribute to a more welcoming environment for the vulnerable migrants that benefits both migrants and host communities.

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Appendix 1

Components Selection Criterions

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Kaiser criterion: 4.000000

95% threshold criterion: 6.000000

Eigenvalues:
 3.48667
  1.8512
 1.23913
 1.14457
0.708754
0.626396
0.481818
0.210214
0.190953
0.060303
```

Principal Components

Variable Loadings:

	PC1	PC2	PC3	PC4
cpi	0.463346	0.0704588	0.137025	0.0425624
inf_mort	-0.284706	0.290686	-0.167421	0.54367
life_exp	0.455056	-0.132947	-0.0751152	0.0388485
med_inc	0.488289	0.175423	-0.0886221	0.164757
PovR	-0.270992	-0.31892	-0.134509	0.538166
urb_pop	0.353967	-0.105591	-0.154895	0.300835
prop_65	-0.0960729	-0.505635	0.465138	-0.21911
FertR	-0.132463	0.334176	0.562047	0.184737
healt_xp21	0.18233	-0.1606	0.567699	0.438307
unemp_r	-0.00146853	-0.596739	-0.20756	0.139942

Squared correlations:

	PC1	PC2	PC3	PC4
cpi	0.748551	0.00919014	0.0232657	0.00207344
inf_mort	0.282621	0.156423	0.0347328	0.338307
life_exp	0.722004	0.0327198	0.00699152	0.00172739
med_inc	0.831311	0.0569672	0.00973196	0.031069
PovR	0.256048	0.188285	0.022419	0.331492
urb_pop	0.436853	0.0206399	0.0297299	0.103585
prop_65	0.0321819	0.47329	0.26809	0.0549499
FertR	0.0611785	0.206729	0.391438	0.0390615
healt_xp21	0.115912	0.0477466	0.39935	0.219887
unemp_r	7.51838e-06	0.659207	0.0533834	0.0224149