Osmosis: The Unifying Theory of Human Migration

Samir DJELTI* **

Abstract

This paper presents a unifying theory that explains human migration. Unlike the gravity theory, this one is based upon the osmosis phenomenon. In biology, the determinants of osmosis are measured by the number of moles of gas molecules, the Gas constant, the temperature in kelvins and the volume of the cell. Relying on this model, the determinants of osmosis are intuitively replaced with the natural determinants of human migration (water, climate, security, and density). Moreover, the determinacy of GDP and the location, explained by the distance, are added to the final estimation. The estimation outcome of the OLS regression of 93 countries during 1970, 1980, 1990, and 2000, reveals that the osmosis model represents a strong and significant explanation of human migration. In addition, GDP is not a strong determinant of migration, it just reflects the natural determinants. Human migration is, then, a matter of strong powers of an evolutionary natural pressure between regions.

Key words: *Human Migration, Natural determinants, osmosis.*
Jel Classification : *F22*

1. Introduction

Throughout history, migration has proved to be an increasingly debated topic. Several events have dogged this phenomenon to the center of academic and political arenas. This is particularly evident through the fact that: "More than 43 million people worldwide are now forcibly displaced as a result of conflict and persecution, the highest number since the mid-1990s. Several million people remain displaced because of natural disasters (…) More than 15 million of the uprooted are refugees who fled their home countries, while another 27 million are people who remain displaced by conflict" (UN, 2016). In addition to the studied types of migration, other specific forms have emerged and studied, notably climate migration, lords of sun and LGBTQ migration[1]. Moreover, each of these forms of migration could be explained by several determinants and may therefore lead to other specific forms. Such specific forms of human migration are interrelated because they have the same origin. Put differently, crises migration creates refugees, who could be also asylum seekers and economic migrants.

Theoretically, there are about twenty migration theories (Bijak, 2006). They coexist and explain this phenomenon in some places, but not in others, during some periods, but not during others. These theories belong to their specific disciplines such as geography, sociology, and economics. Yet, one has to precise the nature of migration, as it can be voluntary or forced, regular or irregular, and temporary or permanent. Such theories explain migration according to the limited view of their corresponding disciplines. Dividing migration relying on causes, nature, location, or time, and trying to explain the part corresponding to the discipline can never lead to a complete and thorough explanation.

* Mustapha Stambouli University, Mascara, Algeria. E-mail: samirecodjelti@yahoo.fr
** I thank Dr. Houari MIRED for his comments and corrections.
[1] The lesbian, gay, bisexual, transgender, and queer migration because of discrimination and ill treatment.

For example, economic migration concerns workers pushed by economic factors like poverty and unemployment in the home country and pulled by high wages and better job prospects in the host country. In the same vein, refugees are also forced by economic factors in addition to conflicts in the home country. Once in the host country, refugees affect the economies of both home and host countries. It is worth noting that the above mentioned classification and this partial analysis of a unique phenomenon cannot provide a general, logical and complete explanation.

In reality, there are few attempts to set out a theoretical unifying framework to modelize migration. The migration systems theory (Mabogunje, 1970 in Kritz et al., 1992) gathers migrations, which have the same characteristics in a dynamic system. Both on the micro and macro levels, these systems are in perpetual interplay with historical, economic, cultural and political ties between the concerned countries (Bijak, 2006). The logic of this theory considers migration as the most important interaction, which have a reciprocal causality with the other interactions. Zlotnik (1998) reckons that this synthesizing and multi-perspective approach can present an advantageous model, but it remains almost impossible to be implemented because of its complexity.

Massey (2002) proposes another unifying model, in which he combines three factors, namely the duration-of-stay effects, the notion of migration transition, and the multidisciplinary determinants. The sociologist defines the post-industrial migration as an outcome of the socio-economic development and the integration processes. As the former model, this one is far from forecasting the whole migration phenomenon, and seems very difficult to apply in reality (Bijak, 2006).

The idea of combining the existing determinants in a mathematical model represents also a unifying model. Such a model could explain a big part of human migration, but its application proves complicated. The problem is in the use of mathematics as the main forecast instead of a tool of analysis. In other words, to explain the whole phenomenon of human migration, demonstrating mechanical relations between the determinants cannot work. Observing and defining the nature of this interaction is necessary before any recourse to mathematics.

The gravity model is largely used as a forecast to estimate international trade. The analogy suggests that the movements of goods, together with the other matters, are also explained by the law of universal gravitation. The idea of this analogy seems to be logical. That is why the model is theoretically accepted. Consequently, the majority of the empirical studies demonstrate the strong capacity of the model to predict international trade. The application of this model extends and proves its capacity to explain the other international interactions, such as foreign direct investment and international migration.

To explain human migration, the gravity model cannot take into consideration the human side of this mobility. To put it simply, humans are not goods. They have feelings, needs, preferences, relationships…etc. The rationale of this study is to find **the unifying model that can explain the whole phenomenon of human migration.** To do so, two major steps are necessary. The first one consists in simplifying the whole phenomenon of human migration in order to understand it while the second is to find the adequate model, which explain it. In a former study (Djelti, 2017), the first step was done; human migration was simplified, its history was summarized, and its main determinants were defined. Therefore, the aim of this paper is to achieve the second step.

2. *Theoretical Background*

The push and pull factors theory of migration, initially developed by Lee (1966), remains up-to-date the most logical explanation used by the majority of disciplines. It provides a large forecast for analyzing migration flows by considering all the possible determinants whether push or pull factors.

Even the migration networks can be considered as a pull factor that affects people who share kinship, friendship or just the origin (Taylor, 1986). Other socioeconomic theories, namely the cumulative causality (Massey, 1990) and the institutional theory (Massey and *al.*, 1993) consider migration as an evolutionary process. According to these theories, income, land, capital, networks and institutions explain this migration.

The micro-economic theories insist on wage and employment as the main factors (Lewis, 1954 ; Harris and Todaro, 1970) while the macroeconomic ones divide migration into world systems (Wallerstein, 1974) or explain it by the demand in the segmented markets of the host countries (Pior, 1979). In addition, the theory of new economics of labour migration (Stark and Bloom, 1985) predicts that migration is based on household decision in order to improve its standard of living.

According to Anderson (2011), Ravenstein (1885, 1889) was the first who used the gravity law to explain migration. Human geographers (Stewart, 1941; Zipf, 1946) used the same model and considered population and distance as the main determinants. In addition, Isard (1965) replaced the mass and the distance of the gravity equation with the population and the distance to estimate the spatial interactions. To him, spatial interactions represent the movement of goods, people, and ideas within and between regions. In the same order of vein, Lowry (1966) argued that different variables can replace the mass of the gravity model, notably unemployment, wage, numbers of persons in civilian labour force and the armed forces (Bijak, 2006). Furthermore, Wilson (1967 - 1970) proposed that interactions between two regions can be measured by the law of the *entropy*[2]. These theories do not take into consideration neither the sociological determinants nor the economic ones. That is why scientists do not use them to make predictions.

In economics, the gravity model was analogically proposed for the first time by Timbergen (1962) to explain trade flows between countries. Recently, there has been an explosion of empirical studies that make the gravity model the most predictable model of international trade. What is even more surprising, is that the model does not request a sophisticated mathematical demonstration[3]. It represents the newton law on the universal gravity, which, four centuries later, could explain also the flow of goods.

The gravity theory in both economics and geography was proposed intuitively for explaining spatial interactions. Some economists (Anderson, 1979 ; Eaton and Kortum, 2002 ; Chaney, 2008 ; Arkolakis, Costinot and Rodriguez-Clare, 2012 ; Head and Mayer, 2013) question the strong capacity of the model to explain trade intuitively. Relaying on different assumptions, they try to justify the explanation capacity of gravity. For example, Chaney (2013) considers that explaining international trade by GDP is well understood while the role of distance remains a mystery.

Because of the lack of bilateral migration statistics, few empirical studies use the gravity model to explain migration. The model used is not that different from the one used for trade. GDP, population, and distance remain the main determinants of these studies (Mayda, 2010 ; McKenzie, Theoharides and Yang, 2013 ; Bertoli, Moraga and Ortega, 2013 ; Ortega and Peri, 2013). In addition, to strengthen the model, researchers use migration policies, expectations, unemployment, environmental factors, and other dyadic factors as networks, bilateral migration policy, language and culture.

Empirically, in the perspective of a unifying explanation[4], a number of studies use the gravity model. Karemera, Oguledo and Davis (2000) investigate the main determinants of migration to the USA.

[2] The transformation from order to disorder measured by the thermodynamics.
[3] Krugman (1980) demonstrates that trade flows are proportional to country size, and adversely affected by trade barriers.
[4] Without specification of sociological, geographical or economic aspect.

Other studies focus on the same topic for the last decade (Hatton and Williamson, 2007 ; Borjas, 1987; Borjas and Bratsberg, 1996). Mayda (2008) investigates empirically[5] the economic, geographical, cultural, and demographic determinants of bilateral migration. This study concludes that income and opportunities in the host country and GDP per capita in the home country are the main determinants of international migration.

Beine and Parsons (2013) analyze the effect of environmental fluctuations on international migration by dividing these determinants into unexpected short-run factors[6], long-term climate change, and climate variability[7]. They estimate a panel data of bilateral migration from 1960 to 2000 and conclude no direct effect of climate change on international migration. The robustness of their model is related to the conditioning characteristics of the home countries and the endogenous potential of the network variable. The results demonstrate an indirect environmental effect correlated with wages and greater flows of cities' immigrants caused by natural disasters.

In general, according to the literature, international migration is mainly dominated by economic, sociological, and geographical determinants. Relaying on this division, the migration determinants are embedded in these different disciplines. Even the gravity model, considered as the best unifying model, uses the same logic because the determinants included belong to their specific disciplines. For instance, in addition to the control variables, GDP is an economic determinant and distance is a geographical one. Furthermore, the gravity model cannot explain the whole phenomenon of human migration (in terms of space and time) because it was not always based on GDP, networks or migration policies.

For these reasons, any attempt to explain the whole phenomenon of human migration, in contrast of the gravity model, must use determinants that reflect these disciplines. In other words, the disciplines must be embedded in the factors, and not the opposite. The study that centers upon the evolution of the determinants of human migration (Djelti, 2017), shows that water availability, security, climate, and population density are the main determinants of human migration. The disciplines that study migration are embedded in these determinants. For instance, water reflects the economic side, security is social, climate is geographical, and population density contributes in all these disciplines[8]. In addition, these determinants can also explain the first as well as the new migrations. The challenge, in this paper, is to find out the model that can consider all these determinants. To do so, the following analogy is proposed.

3. Osmosis Measure

Biologists use complicated models to explain osmosis. The tools seem similar to those of the economists. They use mathematics and statistics to measure this biophysical phenomenon. Moreover, even biologists propose different models of osmosis. The difference in the gradient of concentration is the first power, which explains the osmosis. In biology, a gradient results from an unequal distribution of ions across the cell membrane[9]. In the human body, osmosis, diffusion and facilitating diffusion represent spontaneous mechanisms[10] assuring the equilibrium of concentration trough cells and organs. In general, the simplest and widely cited experimentation to simplify this phenomenon is:

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[5] Using the OECD data on immigrant inflows into fourteen countries by country of origin during (1980-1995).
[6] Measured by the number of natural disasters.
[7] The author explains it by deviations and volatilities of temperatures and rainfall from and around their long-run averages.
[8] The population density, for instance, can make water rare or abundant, it can affect also the security.
[9] http://www.biology-online.org/dictionary/concentration_gradient
[10] Which does not need energy.

"imagine a U-shaped tube with equal amounts of water on each side, separated by a water-permeable membrane (...) that is impermeable to sugar molecules. Sugar has been added to the water on one side. The height of the liquid column on that side will then rise (and that on the other side will drop) proportional to the pressure of the two solutions due to movement of the pure water from the compartment without sugar into the compartment containing the sugar water. This process will stop once the pressures of the water and sugar water on both sides of the membrane become equal"

(Atkins and de Paula, 2010)

According to this analogy, if ions of water move from low concentrated locations to high concentrated ones, then humans migrate from the less concentrated countries to the more concentrated ones. In this model, the osmosis variables are intuitively replaced with the determinants of human migration in order to measure it. In addition, the concentration is strongly related to the location. The effective gradient of concentration can not be detected in the case of the distant locations. Therefore, it is very important to consider distance, given the effect of power this has on the closest regions, which decreases with the increase of distance.

4. The model

The model assumes that locations in organs are represented by countries and in each country, the gradient of concentration is the same[11]. Whereas, the concentrations differs from one country to another because of borders that represent the semipermeable membrane. In this model, the gradient of concentration is represented by the osmotic pressure, which is measured by the second law of thermodynamics given by the following equation:

$$\boldsymbol{P = nRT/V}$$

Where:
P: Osmotic pressure
n: Total number of moles of gas molecules in the cell
R: Gas constant
T: Temperature in kelvins
V: Volume of the cell
The same model will be taken, then the biological variables will be intuitively replaced with the corresponding natural determinants of human migration, namely water, security, temperature, and population concentration. The osmotic pressure will be represented by the migration pressure and the number of moles of Gas molecules in the cell (n) will be represented by security. In addition, the gas constant (R) will be replaced with water availability and temperature (T) will be replaced with climate. Finally, the volume (V) will be replaced with population density. Therefore, the model will be given by:

$$\boldsymbol{Migpress = \frac{Water \times Security \times Climate}{\text{Population density}}} \text{......................(1)}$$

In this model, migration from country *i* to *j* will happen if the migration pressure in the country *i* is inferior to the migration pressure in the country *j*. In other words, migration from *i* to *j* is negatively correlated with the migration pressure in the country *i* and positively correlated with the migration pressure in the country *j*.

In a previous study (Djelti, 2017) we have assumed that GDP can not be considered as a factor of human migration because it just represents the result of the evolution of the other determinants. In

[11] This model explains also the micro level in which cities could be considered.

other word, GDP absorbs the prediction capacity of the former natural determinants. This variable will be included in the model in order to test this assumption. Furthermore, the effect of the gradient of concentration will be likely to occur between two close solutions. This means that the power of the pressures degrades with the increase of distance. In this model, distance is also, used as a proxy to measure the strength of the effect of migration pressures on human migration.

In general, the model contains two principal determinants. First, the gradient of concentration, that will be measured by the migration pressure in the countries *i* and *j*. If migration happens from the less concentrated country *i* to the more concentrated one *j*, then it supposed to be negatively correlated to the migration pressure of the country *i* and positively correlated to the pressure in the country *j*. Second, the distance between the country *i* and *j*, that is negatively correlated to migration. Relaying on the osmosis analogy, the following model is proposed.

$$\boldsymbol{Mig\ ij = A \times \frac{Migpress\ j/migpress\ i}{Distij}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(\mathbf{2})$$

Where:
Mig ij: Bilateral migration from *i* to *j*.
A: Constant,
Dist*ij*: Distance between *i* and *j*
Migpress*ij*: Migration pressure of *i* and *j* are both given by the equation (1)

5. *Estimations and results*

In what follows, the migration pressure will be calculated for all the countries and the possibility that humans move from low to high migration pressure will be tested. To test, separately, the capacity of the former determinants to explain human migration, in addition to GDP, three different models were proposed. The first one is simple, it considers only the effect of migration pressures in home and host countries.

$$\boldsymbol{Mig\ ij = A \times Migpressj/\ Migpressi}$$
$$\boldsymbol{ln\ Mig\ ij = \mu 0 + \mu 1\ ln\ Migpressj - \mu 2\ ln\ Migpressi + \xi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(\mathbf{3})$$

Then, the second model supposes that migration increase with the rise of the difference of osmotic pressure between countries *i* and *j* and the fall of distance between them.

$$\boldsymbol{Mig\ ij = A \times diffosmpress\ /\ distij}$$

$$\boldsymbol{Ln\ Migij = \mu 0 + \mu 1\ ln\ Diffosmpress - \mu 2\ ln\ dist + \xi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(\mathbf{4})$$

Where:

$$\textbf{Diffosmpress} = \boldsymbol{Migpressj - Migpressi}$$

In order to test the capacity of GDP to explain human migration, the third model considers the three determinants of human migration. The model is given by the following equation:

$$\boldsymbol{Mig\ ij = A \times \frac{Migpress\ j/migpress\ i\ X\ Gdpj}{Distij}}$$

$$\boldsymbol{ln\ Mig\ ij = \mu 0 + \mu 1\ ln\ Migpressj - \mu 2\ ln\ Migpressi + \mu 3\ ln\ Gdpj - \mu 4\ ln\ Dist + \xi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(\mathbf{5})$$

To estimate the above mentioned models, a bilateral panel data on the natural determinants of human migration have been used. This data cover 124 countries for the models (3) and (4) and 93 countries for the model[12] (5) during the periods 1970, 1980, 1990 and 2000. Human migration is represented by bilateral migration available at the World Bank database. To measure water availability, the renewable internal freshwater resources are considered. The data on population is also available in the World Bank database. Security is based on the Global Security Index[13] database, which takes into consideration wars, armed conflicts and interventions for each country. Climate is represented by the average annual temperature for each country available in the World Bank database for the environment[14]. Area and distance statistics are available in the grave data[15]. GDP data is also extracted from the World Bank database.

For the empirical estimation, the variables representing the natural determinants of human migration have been used to calculate the migration pressure according to equation (1) for all the countries of our sample. Then, the three econometric models have been estimated.

Table 1: regressions' recap

Variable	(3) Fixed cross sections effects[16]	(4) Fixed cross sections effects	(5) Fixed cross sections effects[17]
Observations	61504	61504	34596
Migpress i	-0.040930 (0.2703)		
Migpress j	0.084592 (0.0485)*		
Ln Migpress i			-0.162035 (0.0000)***
Ln Migpress j			0.423632 (0.0000)***
LnGdpj			0.453589 (0.0000)***
Ln Diff Migpress ij		0.176083 (0.0001)***	
Ln dist		-0.073227 (0.5232)	-0.183692 (0.1357)
R-squared	0.903000	0.928307	0.933546
Prob(F-statistic)	0.000000***	0.000000***	0.000000***

Notes: p*<0.005; p**<0.01; p*<0.1.**

After the stationarity and the correlation tests (Appendix 1), an OLS regression of the model (3) was estimated. The results show that human migration is negatively correlated with the migration pressure of the home country on the one hand, and positively correlated with the migration pressure of the host country on the other hand. This means that emigration from *i* to *j* happen from the low migration pressure country to the high one.

After calculating the logarithm of migration, the differences between migration pressures, and distance, model (4) was estimated. The difference between migration pressures is positively correlated with migration. However, distance is negatively correlated with it. Precisely, a ten percent increase in the difference of pressure between the countries *i* and *j* increases migration from *i* to *j* by 1.76 percent. Furthermore, a ten percent decrease in the distance between *i* and *j* increase migration by 0.73 percent. In addition to the migration pressure, measured separately or through its differences,

[12] The lake of GDP statistics in some countries and periods has limited our data.
[13] www.securityindex.org
[14] http://climatedataapi.worldbank.org
[15] http://www.cepii.fr/CEPII/en/cepii/cepii.asp
[16] The Hausman test prob is equal to 0,0038, which means that the appropriate model is the fixed effect model with a determination of 90%. The normality test is in appendix 2
[17] Hausman Test Prob = 0,0000

the previous estimation shows the importance of distance as a supporting factor for explaining migration.

The estimation results of the model (5)[18] reveal that migration from *i* to *j* is positively correlated to the migration pressure and GDP of the country *j*. This migration is, also, negatively correlated to the migration pressure in the country *i* and the distance between *i* and *j*. In regression (5), the coefficient of the migration pressure in the host countries is 42.36 %, which means that a ten percent increase in the migration pressure of the host country increases bilateral migration by 4.23 percent. The effect of GDP is also significant and positive with a coefficient of 45.35%. In other words, a ten present increase in GDP of the host country increases migration by 4.53 percent. Therefore, the results show that the pull factors; Migration pressure and GDP in the host countries have a significant and important effect on bilateral migration.

The migration pressure in the home country is negatively correlated with migration. As it is presented in the table 1, the coefficient of the migration pressure is equal to -16.20 %. This means that a ten percent increase in migration pressure of the country of origin decrease migration by 1.62 %. The effect of distance goes also along with the theoretical predictions. Distance has a negative effect on migration, as a ten percent increase in the distance decreases migration by 1.83 %.

The results confirm the predictions of the theoretical model inspired from the analogy of osmosis. Therefore, the osmosis model provides a good explanation of human migration. Moreover, the estimations suggest that migration pressures, GDP, and distance explains significantly 93.35% of migration. While migration pressures explains at its own, within a simple model, 90.30% of the migration flows. Then, GDP is not the main factor and human migration is, then, a matter of pressure due to its natural determinants.

6. Conclusion

The majority of the empirical studies emphasize the strong capacity of the gravity model to explain international trade. The application of such a model has been extended to the other international interactions, notably international migration. In these studies, the derived models from gravity demonstrate its capacity to explain these interactions.

In biology, cells migrate from locations with low concentration to those with high concentration because of the gradual difference. Relaying on this analogy, humans migrate from the less concentrated countries to the more concentrated ones. Therefore, the variables used to measure the concentration are intuitively replaced with the natural determinants of human migration. The model contains three principal determinants. First, the gradient of concentration measured by the migration pressure in the host and home countries. Second, the GDP of the host country and finally, the distance between the home and the host countries.

The findings go along with the predictions of the theoretical model inspired from the osmosis analogy. Therefore, the osmosis model provides a strong and significant explanation of human migration. Overall, the results suggest that migration pressures, GDP, and distance explains significantly 93.35% of migration. While migration pressure explains at its own, within a simple model, 90.30% of migration flows. Then, GDP absorbs the capacity of the natural determinants of human migration to explain it. Human migration is, then, a matter of strong powers of an evolutionary natural pressure between regions, which creates the uprooting of individuals, households or populations and their implanting in new regions.

[18] The stationarity and the correlation matrix is in the appendix 3

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8. *Appendices*

Appendix 1

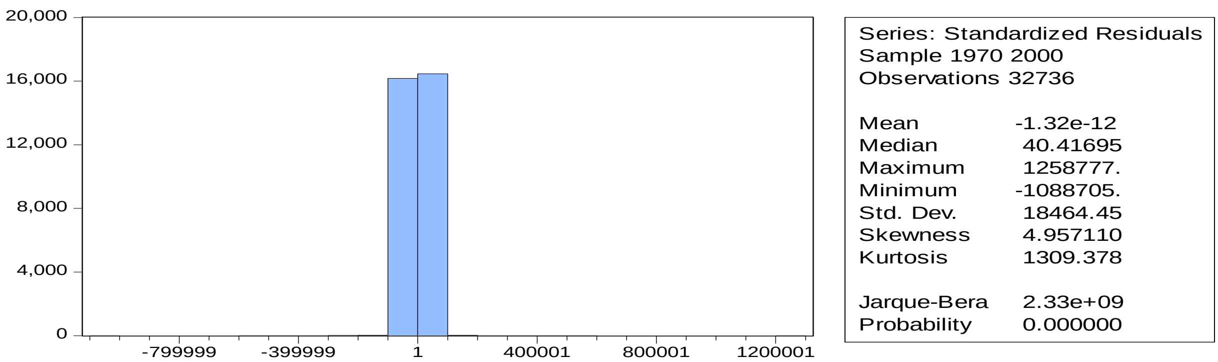
Stationarity tests

Prob	Migration ij	Migpress i	Migpress j
Levin, Lin & Chu t	0.0000	0.0000	0.0000
ADF - Fisher Chi-square	0.0000	0.0000	0.0000
PP - Fisher Chi-square	0.0000	0.0000	0.0000

Correlations matrix

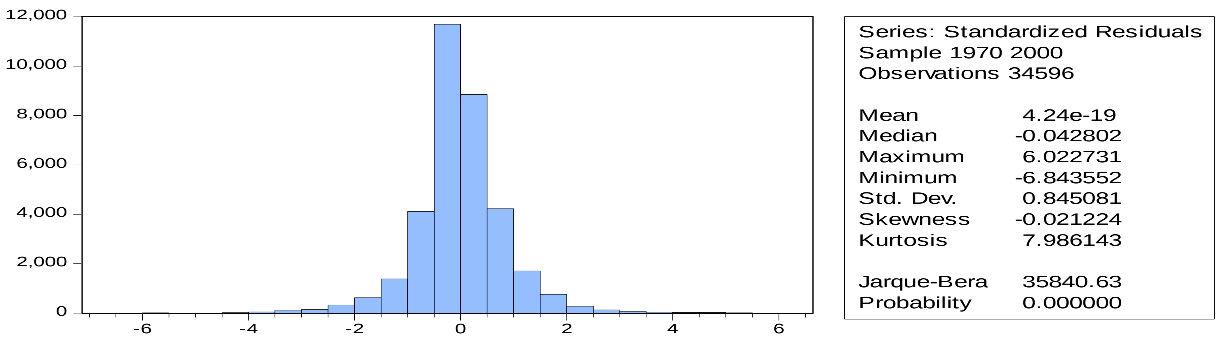
	Migration ij	Migpress i	Migpress j
Migration ij	1	-0.01077441632032689	0.04376853701853239
Migpress i	-0.01077441632032689	1	0.003295937343890302
Migpress j	0.04376853701853239	0.003295937343890302	1

Normality test



Appendix 2

Normality test



Appendix 3

Stationarity tests

Prob	Migration ij	Migpress i	Migpress j	GDP	Distance
Levin, Lin & Chu t	0.1507	0.0000	0.0000	0.0000	1
ADF - Fisher Chi-square	0.0000	0.0000	0.0000	0.0000	-
PP - Fisher Chi-square	0.0000	0.0000	0.0000	0.0000	-

Correlations matrix

	LNMIG	LNPRESSI	LNPRESSJ	LNGDP	LNDIST
LNMIG	1	0.03928846473535812	0.07868118178467005	0.3897434374660749	-0.305251708379058
LNPRESSI	0.03928846473535812	1	0.00664846248291406	-0.02876702644262824	0.1099282218619918
LNPRESSJ	0.07868118178467005	0.00664846248291406	1	0.06215906013773855	0.1066182733067844
LNGDP	0.3897434374660749	-0.02876702644262824	0.06215906013773855	1	0.05111490627378381
LNDIST	-0.305251708379058	0.1099282218619918	0.1066182733067844	0.05111490627378381	1