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The Impact Of Brain Drain On Economic Growth: Addressing Diaspora Externalities

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Abstract

This study aims at empirically estimating the impact of brain drain on economic growth and the impact of brain drain's externalities on this relation. This study used a two-way fixed effects model as an estimation methodology based on data from 140 developing countries from 2007 to 2022.The study find that brain drain has a positive impact on economic growth. This is confirmed by the impact of talent migration, which is assessed by the values of case studies ('The Human Flight and Brain Drain' sub-index Fragile States Index). In addition to, there were linear relationship between brain drain and economic growth and non-dynamic relationship between them, Furthermore, the study examined the impact of income levels and regions on the relation. It finds that the lower the income, the greater the positive impacts of brain drain. Also, it finds that brain drain has a positive effect in some regions and a negative effect in other regions, and it has no effect in other regions. Moreover, the study used interaction variables or moderator variables to examine the impact of brain drain through its externalities on economic growth. The study concluded that brain drain still has a positive impact on economic growth; however, the impact of brain drains externalities is negative. This reflects the great importance of remittances, which are excluded from the brain drain's 'externalities due to their inclusion in the brain drain index. Remittances play an important role in the most developing countries, especially low-income countries.

Keywords: *Human flight &brain drain, Economic Growth, Developing countries, Externalities.*

1. Introduction

The rate of international migration has grown in recent decades. According to the UN, the number of international migrants grew from 72 million to around 244 million between 1960 and 2015, with a growing proportion of them concentrated in high-income nations (H. A. Hadi & Flayyih, 2024). Given the growing income disparity and disparities in demographic forecasts in industrialized and developing nations, the situation is anticipated to worsen in the next decades. This is a worldwide phenomenon which is called brain drain, and its impact on countries of origin has attracted i[1]ncreased attention of policymakers, scientists, and international agencies (Flayyih & Khiari, 2023; A. H. Hadi, Abdulhameed, et al., 2023). It has adverse consequences on developing countries' capacity development and economic growth because most intellectual immigrants who leave their home country are scientists or academics whose contributions are lost value-added for their countries (Docquier & Rapoport 2012). More

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than 5 million persons immigrated to OECD nations in 2010, representing a 40% increase from 2000 (Grogger and Hanson, 2011). Furthermore, persons with greater skill levels are more likely to relocate outside of these nations than those with lower ability levels. According to the World Bank (2007), more than 44% of African people who completed their education abroad, particularly PhD degrees, refused to return home between 1986 and 1996. In order to appreciate brain drain as a problem, brain drain will be defined as the transfer of a specialized set of people such as medical doctors, engineers, scientists, and academics, among others, from one nation to another. Commonly for higher wages or the quality standard of living, access to advanced technology, and more stable political conditions in different places worldwide (Abdullah & Bin Mansor, 2018). Brian drain can also be seen as losing the most educated individuals and expertise by moving human capital to a more conducive environment, especially from developing countries to developed countries (Abdulzahra et al., 2023). Brain drains, also known as human capital flight, refers to the movement of people, particularly the most skilled and competent individuals or manpower, from developing countries to developed countries where they believe the returns on their human capital are valued (Chimanikire, 2005; Dauda, 2018). There are several ways that brain drain might impact the growth and development of the home countries. Remittances (for a survey, see Rapoport and Docquier, 2006), return migration, and the role of migrant networks (or Diaspora effects) are the primary pathways found in the research (A. H. Hadi, Ali, et al., 2023; Hasan et al., 2023; Nehme et al., 2023). The negative impacts represented in the number of intellectuals who leave the country are mostly highly educated; many of them even hold scientific titles and degrees. Consequently, their departure has a number of negative effects on their home country: first, they are viewed as a loss investment because they have used government funds for their education and have not given anything back to the country of origin; second, the migration lowers the number of intellectuals in the nation, which lowers intellectual capital and will negatively affect the level of human capital, which will slow down and struggle the development of the origin country (Marku, 2015). Poor institutions usually capture the expected negative effect of brain drain on economic growth in developing nations in order to encourage migrants to stay and contribute in their economies (Gibson & McKenzie, 2010). It is very likely that skilled migration has some positive effects on developing countries, as evidenced by remittances from migrants to home countries, knowledge and technology acquired from abroad, and increased human capital accumulation if they decide to return (Docquier & Rapoport 2012).furthermore, Diasporas also help to build scientific networks and spread scientific and technological information (Meyer, 2001; Kerr, 2008; Agrawal et al., 2008), promoting technological adoption in migrants' home countries. Indeed, migration provides a safety net, which can relieve economic and political pressures to reform. Migrants can participate in economic and political actions (for example, lobbying to support or prevent development funds) that influence the institutional growth of their home country. So, this study aims to examine the impact of brain drain on economic growth in the developing countries and investigate the possible effects of Diasporas' externalities. The remainder of this study is organized as follow literature reviews & hypothesis development, model structure, data description& methodology results &discussion and conclusion.

2. Literature reviews and hypothesis development

The theoretical literature on the brain drains from 1970 to 1980 demonstrated the relationship between human capital and skilled emigration prospects using mechanisms such as labor market (wage and unemployment) effects, fiscal losses, and aggregate productivity responses. They discovered that the emigration of skilled labor may lower the overall productivity and wages in the sending (native) country, and as a result, the home country suffers from welfare loss (Bhagwati and Hamada 1974; Bhagwatie and Rodriguez 1975; McCulloch and Yellen

1977). Twenty years later the endogenous growth idea was first presented. Miyagiwa (1991) examined the problem of skilled labor migration within the framework of the growth theory of human capital accumulation. He discovered that a greater number of individuals in the less developed nation are prepared to go to school and leave for the more developed nation in order to earn higher wages. Subsequently, Haque and Kim (1995) introduced an overlapping generation growth model in which diverse individuals live for two periods and have the option to divide their early years between employment and study. Individuals have varied levels of acquired human capital. He can only work as he ages. Additionally, he demonstrated how every person inherits the average degree of human capital from the generation before them. Each person is unique in that his or her aptitude to learn differs from that of others. However, Galor and Tsiddon (1997) assumed that an individual totally inherited his or her parents' degree of human capital.

Despite various assumptions and construction, the key conclusions of the second-generation brain drain models remain the same. They all discovered that talented migrants might reduce the overall human capital stock in the home nation, which is known as the brain drain effect. The third generation of brain drain literature reveals an additional force of brain gain effects operating in the opposite direction. Uncertainty over the ability to move may result in lower overall higher education attainment and human capital stock for the sending nation (Hua, 2011). Since the mid-1990s, a newer wave of studies has emerged that discuss the ambiguous effect of brain drain on human capital accumulation and highlights other externalities due to the presence of a Diaspora abroad. They have written on the probability of employment in an external country increases the level of human capital in the home country. This occurs because the prospect of emigrating influences human capital production by providing a positive externality for the home nation and a potential gain for the receiving country (Mountford, 1997; Stark et al., 1997, 1998; Beine et al., 2001, 2008, Docuquier, Iftihkar, 2019). Existing networks between migrants and their countries of origin - contribute in part or whole. These contributions can be made directly through brain trading and virtual returns, or indirectly through creation and development networks, to completely compensate for the loss of human capital as a result of migration. Business networks (such as trade and foreign direct investment), scientific networks (such as technology transmission), and political networks (such as institutions) are examples of the latter. (Berger, 2022)

It also shows positive externalities such as enhanced business opportunities, knowledge of new markets, improved trade, lower transaction costs, and easier access to information, goods, and services emerge depending on the network selected, which ultimately play a vital role in promoting sustainable development in the country of origin and integrating them into the global market. (Terrazas, 2010; Berger, 2022).

Furthermore, Savvides and Stengos (2009) demonstrated in the last two decades that if people's skills, knowledge, and expertise are vital capital for a country's development, then their loss through emigration is seen to have negative consequences on economic growth and negatively affects a country's GDP growth. Dustmann, Fadlon, and Weiss (2011), on the other hand, used the dynamic royal model as a foundation for their models and discovered that migration return can contribute to brain drain mitigation or even brain gain, as people who return bring the home country argument local talents.

In addition to, Mountford and Rapoport (2011) used a dynamic two-country model of the international economy to examine the impact of brain drain on human capital accumulation in both the home and host nations. They discovered that skilled emigration from poor to wealthy nations may, in the long run, enhance inequality in the global income distribution as relatively poor countries rise in population size. Docquier and Rapoport (2012) made the most significant contribution to current research by attempting to overcome the absence of adequate comparison data on international migration by educational attainment. Their empirical research reveals that

brain drain can have a favorable economic impact on those who remain, especially when the degree of positive selection in emigration is not too high.

In 2019 Docquier and Iftikhar used a two-sector model with official and informal labor markets to demonstrate the consequences of brain drain on development and inequality. They conducted their model on 33 Sub-Saharan African nations and provided comparative results for each; they discovered that skilled emigration causes diverse welfare losses among the low-skilled population. Moreover, new studies used a new mathematical models such as DSGE models to investigate the effect in the sending and receiving countries like the study conducted by Bongers ; Díaz-Roldán and Torres in 2022, They studied the impact of international labor migration on human capital investment in both destination and origin countries using an integrated theoretical framework. they found that migration increases world human capital, increasing the stock of human capital in both destination and origin countries. In summary, a limited amount of literature has suggested that the discussion surrounding skilled international migration in the twenty-first century and beyond is best understood in terms of the contribution that skilled migrants have made to the creation of global knowledge and the advancement of technology in a world where there are large differences between nations in terms of their ability to produce and access knowledge and technology (solimano, 2002). Some have a contrary perspective and contend that skilled migration, particularly from poor nations, results in sending countries losing their human capital and skill sets (Fourie, 2006; Erhaga, 2010).

Thus, this study examined the impact of brain drain on economic growth in developing countries and investigated the possible effects of Diaspora's externalities based on two hypotheses:

- The main hypothec is brain drain may decrease economic growth in developing countries.
- The secondary hypothec is Brain drain may increase economic growth through its externalities in the developing countries.

3. Model structure

Following endogenous growth theory, emigration theory and the empirical studies of Adeyemi, Joel, Ebenezer& Attah (2018) and Oliinyk, Bilan, Mishchuk, Akimov & Vasa (2021). this study examined and measured the impact of brain drain on economic growth in the following model:

$$\mathrm{GDP_{it}} = \beta_0 + \beta_1 \mathrm{BD_{it}} + \beta_2 \mathrm{FDI_{it}} + \beta_3 \mathrm{GFCF_{it}} + \beta_4 \mathrm{OPENESS_{it}} + \beta_5 \mathrm{DEPTH_{it}} + \beta_6 \mathrm{HC_{it}} + \beta_7 \mathrm{TFP_{it}} + \beta_8 \mathrm{TFPGAP_{it}} + \beta_8 \mathrm{WGI_{it}} + \varepsilon_{it} \quad (1)$$

Then, the study examines the dynamic effect to answer this question" does brain drain in the previous year's effect on the economic growth in the current year? By using the following model:

$$\mathrm{GDP_{it}} = \alpha_0 + \alpha_1 \mathrm{BD_{it}} + \alpha_2 \mathrm{BD_{it-1}} + \alpha_3 \mathrm{FDI_{it}} + \alpha_4 \mathrm{GFCF_{it}} + \alpha_5 \mathrm{OPENESS_{it}} + \alpha_6 \mathrm{DEPTH_{it}} + \alpha_7 \mathrm{HC_{it}} + \alpha_8 \mathrm{TFP_{it}} + \alpha_9 \mathrm{TFPGAP_{it}} + \alpha_{10} \mathrm{WGI_{it}} + \varepsilon_{it} \quad (2)$$

$$\mathrm{GDP_{it}} = \alpha_0 + \alpha_1 \mathrm{BD_{it}} + \alpha_2 \mathrm{BD_{it-1}} + \alpha_3 \mathrm{BD_{it-1}} + \alpha_4 \mathrm{FDI_{it}} + \alpha_5 \mathrm{GFCF_{it}} + \alpha_6 \mathrm{OPENESS_{it}} + \alpha_7 \mathrm{DEPTH_{it}} + \alpha_8 \mathrm{HC_{it}} + \alpha_9 \mathrm{TFP_{it}} + \alpha_{10} \mathrm{TFPGAP_{it}} + \alpha_{11} \mathrm{WGI_{it}} + \varepsilon_{it} \quad (3)$$

To examine and measure the possible effects of diasporas' externalities the study used moderator or interaction variables that represented in brain drai' s externalities which are expressed by using this formula (BD*HC), (BD*TFP), (BD*TFPGAP), (BD*WGI) to analyze relation between brain drain and economic growth in the following model:

$$\mathrm{GDP_{it}} = \emptyset_0 + \emptyset_1 \mathrm{BD_{it}} + \emptyset_2 (\mathrm{BD} \times \mathrm{externalities})_{it} + \emptyset_3 \mathrm{FDI_{it}} + \emptyset_4 \mathrm{GFCF_{it}} + \emptyset_5 \mathrm{OPENESS_{it}} + \beta_6 \mathrm{DEPTH_{it}} + \beta_7 \mathrm{HC_{it}} + \beta_8 \mathrm{TFP_{it}} + \beta_9 \mathrm{TFPGAP_{it}} + \beta_{10} \mathrm{WGI_{it}} + \varepsilon_{it} \quad (4)$$

Where: t: refers to the time (**t**=1,2 T=39); i: refer to the country; β_0, α_0, $\emptyset_0$: refer to constant coefficient in equations (1), (2 & 3), (4) respectively. β_j, α_j, $\emptyset_j$: refer to coefficient regression for the independent variables in equation (1), (2 & 3), (4) respectively; ε_{it}**:** disturbance term or error. These models are estimated by using the two-way fixed effect models with white diagonal standard error through E-views programs.

4. DATA

This study used independent variables such as human flight and brain drain indicator it is an important indicator of the migration of highly skilled workers, which assesses the impact of displacement on the country's economic development. Such migration can be both voluntary - due to the deteriorating economic situation in their country and the search for better opportunities abroad and forced (persecution or repression). Estimates of this indicator should be interpreted on the basis that the lower the score is, the better it is. That is, a low score indicates an improvement in the area of brain drain and relative stability in this area, while an increase in the score negatively characterizes the situation with brain drain in a particular country. The study also used control variables which have a great impact on the economic growth such as foreign direct investment(FDI) as a percentage of GDP which represent one of the most important Technology transfer channels between countries, it transfers the latest technology of production, administrative and marketing expertise from developed countries to developing countries and creates job opportunities, which contributes to reducing unemployment, gross fixed capital formation (GFCF) as a percentage of GDP which represent the major factor of production and one of the main reasons of economic growth, trade openness as a percentage of GDP which is one of the most important channels of technology transfer between Countries, it helps investments, whether foreign or local, to import modern machinery necessary for local production, in addition to providing raw materials and intermediate goods. If it is not available locally, it also allows opening new international markets for local products.

Domestic credit to the private sector as a percentage of GDP which provides the necessary financing to establish productive projects, whether small, medium, or large, which enhances production and leads to an increase in the size of the local market. The study also used interaction (moderator) variables which express brain drain 'externalities to examine the indirect impact of brain on economic growth through these channels. So, the study used human capital index (HC) to examine the negative consequences which include a decrease in the stock of human capital and the positive consequences that represented in acquiring knowledge and education from abroad which increase human capital accumulation if they decide to come back. it also used total factor of productivity (TFP) and (TFP gap) to express the technical progress in the country and the technical gap between countries to determine the technology diffusion and it's impact on the home country which may be positive by acquiring technology from abroad and may be negative by increasing the technical gap between developing and developed countries. In addition to, using world governance indicators to express the culture that transfers between countries through Diaspora communities and return migration that affect on the institutions on the home country. Migrants can participate in economic and political activities that influence the institutional growth of their home country (for example, lobbying to attract or prevent development funding). Furthermore, the existence of migratory networks outside enhances the exposure of the home country population to foreign values and conventions, as well as the likelihood of movement for those left behind. Migration can affect the incentive structure faced by individuals at home and modify their choices in terms of education (McKenzie and Rapoport, 2006, Beine et al., 2008), talent allocation between productive and unproductive activities (Mariani, 2007), or fertility, which can in turn influence the evolution of home country institutions.

The study excluded remittances which consider the most important one of the externalities or the channels that brain drain affect on the economic growth because brain drain

indicator include the economic impact which represented in remittances, so the study excluded it to avoid the duplication in examining the relation. To measure and examine the relation between brain drain and economic growth the study used a sample of 140 developing countries during the period (2007-2022) the study applied this period because the brain drain indicator is available only at this period .it relied on three international databases (WPI-FP-PWT) to obtain the data necessary to express the study model variables. The table (A) in the appendix indicates the model variables description and it‘s sources.

5. Results and conclusion

5.1 Statistical description of the data

To determine the nature and characteristics of the study's structural model variables, the study used appropriate descriptive statistics, such as the mean and median which is one of the measures of central tendency, the standard deviation, which represents one of the measures of dispersion, the minimum and maximum, in addition to a test Bera-Jarque to investigate the normal distribution of variables. The following table (2) indicates a summary of descriptive statistics.

The results indicate that the brain drain mean and the economic growth mean in the developing countries is 6.14 and 3.45 respectively. So the table 4.3 statistics remain less effective because they reflect the average variables for all developing countries used in the study, therefore to obtain more effective and comparable statistics. The means of these variables were compared between countries, whether on the basis of income level or regional level as indicated in the following table (3).

Table (2): Descriptive summary statistics

	Unit	Obs.	Mean	Median	Std. Dev.	Min	Max	Normality test
Dependent Variable:								
GDP growth	(Annual %)	2195	3.457	3.877	5.826	-50.34	86.83	[95247.6][a]
Independent Variables:								
Human flight & Brain drain	(scale 0 - 10)	2222	6.147	6.4	1.578	1.1	10	[89.9941][a]
ControlVariables:								
1) Economic determinants								
FDI, net inflows	(% of GDP)	2178	4.331	2.881	6.958	-40.09	106.6	[424662][a]
Domestic investment	(% of GDP)	1918	23.65	22.55	8.363	2.178	81.02	[2175.48][a]
Trade openness	(% of GDP)	1988	80.99	73.86	39.99	2.699	347.9	[1381.23][a]
Financial depth	(% of GDP)	1949	39.51	31.54	30.28	0.004	185.4	[1134.23][a]
2) Brain drain externalities								
Human capital	(scale)	1430	2.361	2.418	0.619	1.136	3.849	[52.3005][a]
Technical level (TFP_i)	(Constant LCU)	1079	1.018	1	0.158	0.426	2.407	[39680.3][a]

Technical gap (TFP_i/TFP_l)	(Constant LCU)	1079	1.039	1.007	0.165	0.444	2.506	[38396.1][a]
Institutions (WGI)	(scale 0 - 100)	2240	37.68	36.72	20.48	0.314	87.14	[82.3293][a]

Note: - a, b, c indicate significance at 1%, 5% and 10% respectively.

Table (3): Comparing median variables between income levels and regions

	Income levels				**Regions**					
		Middle income								
	Low income	Lower	Upper	High income	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	South Asia	Sub-Saharan Africa
Dependent Variable:										
GDP growth	4.411	4.5	3.315	2.975	5.417	3.576	3.058	3.065	5.684	4.195
Independent Variables:										
Human flight & Brain drain	7.3	6.8	5.8	4.3	6	5.15	6.5	5.15	6.9	7.1
Control Variables:										
1) Economic determinants										
FDI, net inflows	2.805	2.302	2.984	3.805	3.157	3.493	3.599	1.793	0.919	2.747
Domestic investment	20.15	24.37	22.02	24.12	27.07	22.89	20.81	23.52	28.81	21.02
Trade openness	53.91	69.51	75.69	111.7	99.29	95.69	65.42	82.86	46.01	60.80
Financial depth	11.71	24.59	42.39	48.75	50.98	41.70	40.69	41.58	39.38	14.94
2) Brain drain externalities										
Human capital	1.566	2.043	2.638	2.876	2.569	3.195	2.654	2.318	1.922	1.710
Technical level (TFP_i)	1	0.989	1.003	1.018	0.974	0.999	1.006	1.007	0.942	1.001
Technical gap (TFP_i/TFP_l)	1.005	1	1.014	1.029	0.988	1	1.024	1.035	0.958	1.012
Institutions (WGI)	21.01	28.05	41.43	68.45	38.08	45	43.82	38.43	33.03	25.43

The previous table (3) indicates that brain drain index is 7.3 in the low income countries and 6.8 in the middle income countries then decreases to be 4.3 in the high income countries .this mean that brain drain decreases as income increases.

This is a logical result because the lower the income level, the greater the desire of individuals to immigrate to obtain a better standard of living, better education, better services, and better wages. According to the region classification brain drain index reached its maximum

value in Sub-Saharan Africa 7.3, because the countries of this region rely heavily on remittances. Migrant remittances are a major source of income in many sub-Saharan African countries, helping to sustain the lives of poor home communities.

The table also indicates that the median value of GDP growth is 4.5, 3.3, and 2.9, respectively. This is because rich countries have exhausted all their opportunities for growth, while poor countries have greater opportunities to achieve higher growth rates. The table also indicates that median values of control variables such as foreign direct investment, domestic investment, financial depth and trade openness increase as income increase. For example, the median value of financial depth is 11.17 and 48.75, respectively, in low-income countries and in high-income countries, and this reflects the large difference between the values compared to the income level.

5.2 Correlation matrix

The following table (4) shows the zero-order correlation analysis between the variables of the study model. These correlations allow the initial verification of the hypothesized relationships, as well as the possibility of the study model suffering from the problem of Multicollinearity.

Table (4): Correlation matrix between study variables

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GDP growth	**(1)**	1									
Human flight & Brain drain	**(2)**	0.097[a]	1								
FDI, net inflows	**(3)**	0.134[a]	-0.077[b]	1							
Domestic investment	**(4)**	0.304[a]	-0.108[a]	0.231[a]	1						
Trade openness	**(5)**	-0.038	-0.386[a]	0.243[a]	0.152[a]	1					
Financial depth	**(6)**	-0.100[a]	-0.499[a]	0.036	0.172[a]	0.328[a]	1				
Human capital	**(7)**	-0.160[a]	-0.528[a]	0.033	0.035	0.467[a]	0.406[a]	1			
Technical level (TFP_i)	**(8)**	-0.009	-0.055[c]	0.096[a]	0.006	-0.049	-0.026	0.006	1		
Technical gap (TFP_i/TFP_l)	**(9)**	-0.007	-0.055[c]	0.105[a]	0.011	-0.043	-0.033	-0.009	0.992[a]	1	
Institutions	**(10)**	-0.104[a]	-0.597[a]	0.127[a]	0.066[b]	0.479[a]	0.501[a]	0.527[a]	-0.031	-0.034	1

Note: - a, b, c indicate significance at 1%, 5% and 10% respectively.

The table shows that the value of correlation between brain drain, and economic growth is (0.097) so, there is a weak positive correlation between brain drain and economic growth, but it is statistically significant at 1%. The reason for this is due to personal remittances, and the availability of opportunities for skilled people to succeed and demonstrate their creativity and abilities in developed countries is better than in developing countries. There is also a weak correlation between GDP growth and some control variables such as FDI, domestic investment, financial depth and human capital, and institutions which are (0.134, 0, 304, -0.1, -0.16, -0.104) respectively. They are statistically significant at a1%.

As for the correlation of the independent and control variables with each other, they ranged from weak to moderately strong. According to Anderson (1990) Correlation coefficients greater than 75.0 indicate that the model may be exposed to the problem of Multicollinearity. So, no possibility of co linearity problem was found between the variables of the structural study model.

5.3 Unit root test

The unit root test is used to determine the stationary of time series. The unit root test is considered a prerequisite for econometric analysis of different time series, as choosing the appropriate estimation method depends on the results of stationary tests. If all variables are stationary, that is, integrated of degree I (0), this supports using these methods such as Pooled OLS, fixed effects model and random effects model. But if the variables contain a unit root and become stationary when taking the first difference, that is, an integral of degree I(1), this supports the use of co integration, while if the variables are a mixture of I(0) and I(1), it requires the use of panel Ardle. (Fuller (1976) indicates that the unit root is not necessarily strong (Roubst) and it is favorable to use multiple tests, so The study will use four different tests to verify the strength of the results such as Levin, Lin and Chu test& Im, Pesaran and Shin test & PP-Fisher test & ADF-Fisher test.

Table (5): Unit root test

	Levin, Lin & Chu (t –stat.)		**Im, Pesaran& Shin (W – stat.)**		**ADF – Fisher (Chi – square)**		**PP – Fisher (Chi – square)**		**Results**
	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend	
GDP growth	-26.378[a]		-21.268[a]		990.51[a]		1195.33[a]		**I(0)**
Human flight & Brain drain	-5.9548[a]		-0.8685		322.69[b]		160.073		**I(0)**
FDI, net inflows	-21.809[a]		-17.321[a]		816.79[a]		838.319[a]		**I(0)**
Domestic investment	-8.2660[a]		-4.5319[a]		402.96[a]		442.293[a]		**I(0)**
Trade openness	-6.2945[a]		-3.0672[a]		343.91[a]		320.651[a]		**I(0)**
Financial depth	-8.3062[a]		-1.0228		340.65[a]		360.827[a]		**I(0)**
Human capital	20.431	-2.7055[a]	87.783	0.0861	205.49	362.61[a]	229.035	835.501[a]	**I(0)**
Technical level (TFP_i)	-7.3666[a]		-2.4986[a]		217.21[a]		253.231[a]		**I(0)**
Technical gap (TFP_i/TFP_l)	-7.8613[a]		-2.3861[a]		227.76[a]		234.868[a]		**I(0)**
Institutions (WGI)	-4.6887[a]	-8.3761[a]	-0.7560	-3.8485[a]	341.74[a]	384.51[a]	291.747	353.900[a]	**I(0)**

Note: - a, b, c indicate significance at 1%, 5% and 10% respectively.

It is clear from the results of the table that all dependent, independent and control variables were stationary at the same level. That is, they are integrated to the degree I (0), when there is a constant, except for human capital which was stationary at the level in the absence of a constant and a time trend. thus the stationary results support using one of these methods Pooled OLS, fixed effects model and random effects model.

5.4 Measuring the impact of brain drain on economic growth.

To examine the impact of brain drain on economic growth the study used a 2-way fixed effects model with (White diagonal standard errors). It should be noted that this method was chosen based on the Hausman test.

The following table (6) indicates the results of 6 regressions which answers the main questions in the study. Regressions (1, 2, 3) answer the question of what is the impact of brain drain on economic growth in the developing countries? regression (4) answer the question of Does there is maximum level of brain drain on economic growth? Or does there is a nonlinear relationship between brain drain and economic growth? Regressions (5, 6) answer the question of Does there is a dynamic relation between brain drain and economic growth? Or does brain drain in the previous years will affect the current economic growth?.

The previous table (6) indicates that the null model or the Zero-sum regression does not include any independent variables except the function constant. The function constant reflects the average economic growth when the effect of all economic variables is equal to zero. From the results it is clear that the constant is positive and significant. This means that these countries will achieve economic growth even if the effects of economic variables are zero. It indicates the economic growth level when the impact of all independent variables equal zero. The results indicate that the coefficient of the constant is positive and significant at the 1% level. Furthermore, the adjusted R^2 value indicates that the international differences which expressed by dummy variables explained (56.9%) of economic growth in countries. These differences are due to the use of a large sample from different and heterogeneous countries due to the characteristics of each country, such as economic, technological and institutional structures. Transforming to regression (1) which represent Simple linear regression between brain drain and economic growth at 140 developing countries from2007 to 2022 by (2103) observations the study found that brain drain has positive impact on economic growth at significance level 1%.this mean when brain drain increases by (1%) the economic growth increases by (0.2679%) The adjusted R^2 of this regression indicates that brain drain explains less than 1% of all changes occur to the economic growth in these countries. The positive impact is due to the impact of remittances from abroad on the economic growth of these countries which is included in the economic impact of the brain drain indicator.

Table (6): Brain drain and economic growth: Econometrics results
Dependent variables: GDP growth (annual %)
Method:2-way fixed effects model with (White diagonal standard errors)

	Null model	**Reg (1)**	**Reg (2)**	**Reg (3)**	**Reg (4)**	**Reg (5)**	**Reg (6)**
Constant	6.1312 [27.89]***	4.4654 [6.950]***	-0.9260 [-1.082]	-17.932 [- 5.193]***	-15.948 [- 4.426]***	-17.489 [- 4.906]***	-18.045 [- 4.658]***
Human flight & Brain drain		**0.2679 [2.806]*** **	**0.3455 [3.528]*** **	**0.0208 [5.420]*** **	**-0.4485 [-1.087]**	**0.3538 [1.514]**	**0.3324 [1.398]**

Human flight & Brain drain squared				**0.0873 [2.586]*** **			
Human flight & Brain drain(-1)						**0.0319 [0.135]**	**-0.3269 [-0.967]**
Human flight & Brain drain(-2)							**0.3268 [1.370]**
FDI, net inflows			0.0202 [1.458]	0.0208 [1.183]	0.0195 [1.143]	0.0239 [1.434]	0.0225 [1.387]
Domestic investment			0.1235 [8.574]***	0.0759 [3.949]***	0.0712 [3.699]***	0.0647 [3.552]***	0.0567 [3.131]***
Trade openness			0.0329 [6.077]***	0.0422 [6.800]***	0.0415 [6.632]***	0.0409 [6.497]***	0.0461 [6.097]***
Financial depth			-0.0481 [-8.053]***	-0.0551 [-6.408]***	-0.0511 [-5.601]***	-0.0589 [-7.671]***	-0.0679 [-7.612]***
Human capital				2.8171 [2.572]**	3.0801 [2.728]***	3.2512 [2.976]**	2.5689 [2.300]**
Technical level (TFP_i)				81.360 [4.458]***	83.311 [4.367]***	68.639 [1.721]*	67.242 [1.642]
Technical gap (TFP_i/TFP_l)				-72.707 [-4.097]***	-74.425 [-4.011]***	-60.647 [-1.566]	-59.003 [-1.478]
Institutions (WGI)				0.0809 [4.812]***	0.0799 [4.687]***	0.0883 [5.375]***	0.0910 [5.361]***
Key Regression Statistics							
Obs.	2121	2103	1627	931	931	866	799
Unit (Countries)	140	140	124	80	80	80	80
Period	(2007-2022)	(2007-2022)	(2007-2022)	(2007-2019)	(2007-2019)	(2008-2019)	(2009-2019)
Adjusted R-squared	56.9%	57.1%	63.1%	61.6%	62.5%	66.2%	69.6%
Fisher test (F-stats.)	(19.186)***	(19.037)***	(20.474)***	(16.072)***	(16.499)***	(17.911)***	(19.256)***
Effects Specification tests							

Residual variance test	[3.9925]***	[3.9832]***	[5.1035]***	[6.1109]***	[6.0491]***	[5.8485]***	[5.8419]***
Breusch-Pagan test		[391.40]***	[222.07]***	[161.59]***	[163.08]***	[149.39]***	[128.48]***
Hausman test	[392.49]***	[1.2766]	[145.57]***	[122.52]***	[119.61]***	[113.06]***	[121.43]***
Time test	[1066.1]***	[1051.2]***	[767.55]***	[146.49]***	[153.88]***	[129.99]***	[125.76]***

Note: - ***, **, * indicate significance at 1%, 5% and 10% respectively.

According to regression (2) which represent multiple regression model to examine the relationship between brain drain and economic growth in the existence of the determinant variables of economic growth (control variables) at124 developing countries by 1126 observations the study found that brain drain still has positive impact on economic growth at significance level 1%.this mean when brain drain increase by 1% the economic growth increase by (0.3455%) this percentage is greater than the percentage of the determinant variables of economic growth which reflect the important impact of brain drain on economic growth. The impact of control variables is consistent with the economic theory where domestic investment and trade openness has appositive impact on economic growth but financial depth has a negative impact on economic growth. The reason for this is the high rate of corruption in most developing countries, which leads to the lack of a favorable environment for optimal exploitation of financial resources, in addition to the mismanagement that most developing countries suffer from. In regression (3) the study added another controls variables which are necessarily related by brain drain and have an important effect on economic growth such as human capital, technical level, technical gap and culture which expressed by (WGI). This regression considers the main model in the study which examines the impact of brain drain on economic growth at 80 developing countries by931 observations during the period (2007-2019). the results indicates that the impact of these variables are consistent with economic theory for example when human capital increase by 1% the economic growth rate increase by 2.8 also, technical level and WGI have a positive impact on economic growth which are significant at 1% . On contrary when technical gap increases by 1% the economic growth rate decreases by 72.7 this great effect reflect the fact that the more the technical gap between developing and developed countries the lower the economic growth rate in the developing countries. Moreover, the adjusted R^2 increased from 57.1 % to be 63.1%. Regression results (4) indicate that there is a linear relationship between brain drain and economic growth. This means that the effect of the brain drain on economic growth is still positive and will not change after a certain limit or there is no maximum limit to the effect of the brain drain on economic growth. This result is due to the economic impact of remittances included in the brain drain index.

Regressions (5) and (6) examine the dynamic relationship between brain drain and economic growth in 80 developing countries during (2008-2019) and (2009-2019), respectively. The study concluded that the effect is insignificant and that there is no dynamic relationship between brain drain and economic growth, meaning that the brain drain in previous years has no impact on current economic growth. The impact is immediate because the brain drain affects economic growth in the same year. Due to the brain drain index includes the economic effects of personal remittances, which have a direct impact on growth.

Table (7): Positive impact of brain drain on economic growth across countries (n= 114)
Dependent variables:GDP growth (annual %)

Method:2-way fixed effects model with (White diagonal standard errors)

Countries	Coeff. [t-Stats.]	Countries	Coeff. [t-Stats.]	Countries	Coeff. [t-Stats.]
Qatar	4.9311 [2.904][a]	Moldova	0.2721 [2.843][a]	Ghana	0.2649[2.774][a]
Bhutan	4.7530 [2.042][a]	Russian Federation	0.2719 [2.828][a]	Sao Tome & Principe	0.2647[2.762][a]
Lebanon	4.1489 [3.174][a]	Botswana	0.2718 [2.847][a]	Turkmenistan	0.2638[2.762][a]
Eritrea	3.9112 [1.964][c]	Philippines	0.2715 [2.839][a]	Ethiopia	0.2637[2.760][a]
Sudan	3.3978 [2.550][b]	Iran, Islamic Rep.	0.2714 [2.838][a]	Venezuela, RB	0.2637[2.761][a]
Azerbaijan	3.1992 [1.752][a]	Kuwait	0.2710 [2.838][a]	Guinea-Bissau	0.2634[2.751][a]
Belarus	2.7822 [2.265][b]	Latvia	0.2705 [2.828][a]	Lao PDR	0.2633[2.750][a]
Mali	2.7791 [2.451][b]	Guyana	0.2705 [2.818][a]	Indonesia	0.2633[2.719][a]
Albania	2.7573 [4.009][a]	Slovak Republic	0.2702 [2.826][a]	Thailand	0.2632[2.754][a]
Djibouti	2.6991 [3.297][a]	Egypt, Arab Rep.	0.2701 [2.816][a]	Nicaragua	0.2632[2.751][a]
Mauritania	2.6674 [3.200][a]	Yemen, Rep.	0.2701 [2.829][a]	Belize	0.2629[2.754][a]
Guatemala	2.3326 [2.146][a]	Central African Rep.	0.2698 [2.816][a]	Burkina Faso	0.2629[2.747][a]
Senegal	1.9608 [4.887][a]	Viet Nam	0.2698 [2.823][a]	Honduras	0.2628[2.749][a]
China	1.9541 [3.436][a]	Brunei Darussalam	0.2698 [2.824][a]	Grenada	0.2625[2.749][a]
Nigeria	1.9118 [1.937][c]	Mozambique	0.2695 [2.823][a]	Estonia	0.2625[2.748][a]
Uruguay	1.5397 [2.395][a]	Slovenia	0.2694 [2.819][a]	Bosnia & Herzegovina	0.2620[2.732][a]
Fiji	1.5283 [1.979][b]	Bolivia	0.2692 [2.816][a]	Armenia	0.2620[2.744][a]
Jamaica	1.4204 [2.417][b]	Sierra Leone	0.2691 [2.818][a]	Bahrain	0.2619[2.742][a]
Colombia	0.3002 [3.119][a]	Kyrgyz Republic	0.2690 [2.816][a]	Brazil	0.2617[2.738][a]
Mexico	0.2902 [3.028][a]	Myanmar	0.2690 [2.812][a]	Jordan	0.2608[2.708][a]
North Macedonia	0.2837 [2.922][a]	Georgia	0.2690 [2.813][a]	Niger	0.2608[2.727][a]
Dominican Rep.	0.2797 [2.920][a]	Rwanda	0.2687 [2.812][a]	Cambodia	0.2606[2.726][a]

Bahamas, The	0.2794 [2.908]^{a}	Gabon	0.2686 [2.813]^{a}	Argentina	0.2606[2.728]^{a}
Maldives	0.2781 [2.911]^{a}	Chile	0.2680 [2.790]^{a}	Malaysia	0.2602[2.710]^{a}
Syrian Arab Rep.	0.2771 [2.896]^{a}	Ukraine	0.2679 [2.778]^{a}	Haiti	0.2602[2.719]^{a}
Morocco	0.2765 [2.870]^{a}	Somalia	0.2678 [2.805]^{a}	Togo	0.2598[2.726]^{a}
India	0.2760 [2.884]^{a}	Comoros	0.2675 [2.792]^{a}	Suriname	0.2590[2.711]^{a}
Congo, Dem. Rep.	0.2757 [2.876]$_{a}$	Benin	0.2670 [2.795]^{a}	Serbia	0.2578[2.695]^{a}
Uganda	0.2749 [2.867]^{a}	Kazakhstan	0.2668 [2.779]^{a}	Malawi	0.2562[2.680]^{a}
Costa Rica	0.2747 [2.863]^{a}	Sri Lanka	0.2667 [2.786]^{a}	Iraq	0.2561[2.674]^{a}
Chad	0.2743 [2.872]^{a}	Gambia, The	0.2667 [2.777]^{a}	Zimbabwe	0.2549[2.671]^{a}
Mauritius	0.2741 [2.787]^{a}	Peru	0.2667 [2.792]^{a}	Tanzania	0.2537[2.623]^{a}
Panama	0.2738 [2.867]^{a}	Nepal	0.2666 [2.789]^{a}	Cuba	0.2535[2.621]^{a}
Burundi	0.2736 [2.867]^{a}	Papua New Guinea	0.2658 [2.783]^{a}	Uzbekistan	0.2524[2.616]^{a}
Tunisia	0.2724 [2.849]^{a}	Paraguay	0.2657 [2.782]^{a}	Madagascar	0.2524[2.634]^{a}
Romania	0.2723 [2.845]^{a}	Libya	0.2656 [2.772]^{a}	El Salvador	0.2523[2.645]^{a}
Namibia	0.2722 [2.842]^{a}	Seychelles	0.2654 [2.778]^{a}	Equatorial Guinea	0.2522[2.638]^{a}
Cameroon	0.2721 [2.849]^{a}	Lithuania	0.2649 [2.762]^{a}	Ecuador	0.2440[2.515]^{b}

Note: - a, b, c indicate significance at 1%, 5% and 10% respectively.

The following tables (7), (8) show the impact of brain drain on economic growth in each country separately through the total sample of 140 developing countries through panel data analysis using 2 way fixed effects model. The study found that the impact of brain drain is positive in 114 developing countries and is negative in 24 countries.

The study attempts to investigate the countries that have been positively affected by the brain drain to focus on the strategies and policies that those countries have followed to reverse the brain drain into brain gain. Table (7) shows developing countries where brain drain has a positive impact on economic growth. These countries are ranked from most affected to least affected.

The results showed that Lebanon is one of the most positively affected countries by brain drain, as it is an example of a remittance-dependent economy, with a continual outflow of immigrants ensuring consistent inflows of remittances. According to some estimates, Lebanon has an abroad Diaspora of about 14 million people, which is more than three times the size of its domestic population and continues to send billions of dollars home each year. Financial inflows from this Diaspora have been surprisingly stable in the midst of severe political

instability in recent years (Awedh, 2014). As brain drain increase by 1% the economic growth rate increase by 4.1%.

Furthermore, The United Nations Development Program, 2023 indicate that Lebanon's remittances stood at 37.8% of GDP in 2022, which represents the highest ratio in the Middle East and North Africa (MENA) region. In absolute value, Lebanon is ranked as the third highest recipient of remittances within the region.

In the absence of a well-developed and inclusive social protection system, remittances are used to compensate, in part, for the losses in the real value of income triggered by currency depreciation and rising inflation. In addition to the continuous flow of remittances and other financial transfers (such as non-resident deposits and Diaspora investments) indicates a strong relationship between the Diaspora and Lebanon. These financial flows go to investment in local development and play a pivotal role in reversing development losses and charting the country's development path, which reflects the positive impact of brain drain. (UNDP report, 2023)

Table (7) also indicate that brain drain is positively affected economic growth in china when brain drain increase by 1% the economic growth rate increase by 1.9% this is due to the strategies followed by China to reverse brain drain to brain gain.

For example, to gain advantages in the global "talent war", Chinese governments have introduced a series of policies and programs to entice overseas talent to return home since 1978 (Zweig & Wang, 2013), including the "Thousand Talent Program". These programs have helped China reclaim batches of overseas talent, leading to brain circulation between China and developed countries.

Furthermore, China offers enough opportunities and an acceptable quality of life back home to make returning after graduation a reasonable option. It creates new jobs and opportunities for people with talent, capital, ideas and technology. So it benefit from decreasing the expenditure of education on one hand and benefits from the return migration on the other. The study also examines countries that have been negatively affected by brain drain to determine the causes and factors that lead to this effect. Therefore, Table (8) shows developing countries in which brain drain negatively affects economic growth. These countries are ranked from most affected to least affected.

Table (8): Negative impact of brain drain on economic growth across countries (n=24)
Dependent variables: GDP growth (annual %)
Method:2-way fixed effects model with (White diagonal standard errors)

Countries	Coeff. [t-Stats.]	Countries	Coeff. [t-Stats.]	Countries	Coeff. [t-Stats.]
Congo, Rep.	-7.3080 [-3.941][a]	United Arab Emirates	-3.1049 [-2.971][a]	Pakistan	-1.6608[-3.478][a]
Angola	-6.3936 [-7.092][a]	Oman	-3.0178 [-2.837][a]	Lesotho	-1.6495[-2.810][a]
Cabo Verde	-5.7678 [-5.409][a]	Mongolia	-2.9889 [-2.982][a]	Guinea	-1.5946[-1.708][c]
Saudi Arabia	-4.9641 [-2.834][a]	Tajikistan	-2.7186 [-2.934][a]	Kenya	-1.4649[-1.998][b]
Liberia	-4.7310 [-2.337][b]	Barbados	-2.3483 [-2.382][b]	Algeria	-1.1742[-2.460][b]
Hungary	-3.5003 [-5.716][a]	Cote d'Ivoire	-2.0002 [-2.436][b]	Bangladesh	-1.1636[-2.242][b]
Turkiye	-3.4489 [-2.494][b]	Zambia	-1.9383 [-3.088][a]	Bulgaria	-1.0269[-1.762][c]
Antigua & Barbuda	-3.2550 [-3.037][a]	Trinidad & Tobago	-1.8097 [-1.675][c]	South Africa	-0.5154[-3.091][a]

Note: - a, b, c indicate significance at 1%, 5% and 10% respectively.

Previous table (8) shows that brain drain is negatively affected the economic growth in 24 developing countries. The Kingdom of Saudi Arabia is considered one of the most countries that negatively affected when brain drain increase by 1% the economic growth rate decrease by4.96% due to The Kingdom of Saudi Arabia is considered one of the rich countries whose economy depends on oil. According to World Bank data the number of Saudis reached 18.8 million people, or 58.4%, while the number of non-Saudis reached 13.4 million people, or 41.6%, in 2022. This large percentage of foreigners receives wages that they transfer to their homeland. Therefore, the effect of remittances is negative on the economic growth rate. Therefore, brain drain negatively affects its economic growth due to the loss of skilled individuals who represent the country's human capital, which represents the backbone of economic growth. The results also indicate that the brain drain negatively affected economic growth in Turkey, as the brain drain increased by 1% and the economic growth rate decreased by 3.45%. The negative impact is due to Turkey's valuable human resources. In the Global Innovation Index, Turkey ranked 37th in 2022, with a score of 38.81 points. The index is calculated annually by the World Intellectual Property Organization (WIPO), and recently included 132 countries. (Global Innovation Index Database, WIPO, 2022). Therefore, the migration of highly skilled workers hinders development.

The following table (9) shows the relationship between brain drain and economic growth according to the income level of countries during (2007-2019)

Table (9): Brain drain and economic growth across income levels: Econometrics results

Dependent variables: GDP growth (annual %)
Method:2-way fixed effects model with (White diagonal standard errors)

	Reg (7)	**Reg (8)**	**Reg (9)**	**Reg (10)**
	Low income	Lower middle income	Upper middle income	High income
Human flight & Brain drain	**2.3705 [3.414]*** **	**0.2947 [1.704]***	**0.7805 [5.411]*** **	**0.1336 [0.436]**
FDI, net inflows	-0.0383 [-0.806]	0.1069 [3.510]***	0.0325 [0.889]	-0.0084 [-1.188]
Domestic investment	0.0177 [0.363]	0.0449 [1.740]*	0.1196 [2.465]**	0.4547 [7.065]***
Trade openness	0.0217 [0.835]	0.0474 [5.614]***	0.0484 [4.003]***	0.0735 [4.692]***
Financial depth	0.0495 [0.728]	-0.0251 [-2.272]**	-0.0721 [-4.287]***	-0.1125 [-7.535]***
Human capital	7.7241 [0.944]	2.2809 [1.301]	-2.8098 [-1.457]	-3.5037 [-0.591]
Technical level (TFP_i)	-65.904 [-1.675]*	27.606 [1.203]	119.66 [4.438]***	51.305 [1.248]
Technical gap (TFP_i/TFP_l)	70.678	-21.695	-107.99	-52.087

	[1.827]*	[-0.973]	[-4.094]***	[-1.325]
Institutions (WGI)	-0.0363 [-0.519]	0.1029 [4.017]***	0.0398 [1.424]	-0.1157 [-2.431]**
Constant	-30.004 [-2.167]**	-15.105 [-2.944]***	-6.2675 [-0.944]	11.893 [0.726]
Key Regression Statistics				
Obs.	113	308	363	147
Unit (Countries)	9	27	31	13
Period	(2007-2019)	(2007-2019)	(2007-2019)	(2009-2019)
Adjusted R-squared	44.9%	61.2%	64%	75%
Fisher test (F-stats.)	(4.2596)***	(11.529)***	(13.880)***	(14.693)***

Note: - ***, **, * indicate significance at 1%, 5% and 10% respectively.

The results of Table (9) indicate that there is an inverse relationship between brain drain and the income level of countries. The lower the income level, the greater the brains drain. When brain drain increases by 1% in low-income, lower-middle-income and high-income countries, economic growth rates increase at lower rates of 2.37%, 0.29% and 0.13%, respectively. This result consistent with the economic theory .The positive impact is high in low-income countries due to an environment not conducive to success such as lack of spending on research and development, low wages, lack of public services, low welfare , widespread corruption, lack of opportunities, political instability, economic depression, health risks, high unemployment rates and rapid population growth so these countries can benefit from the presence of individuals abroad more than residing in their countries. They benefit from remittances, return migration, human capital accumulation, technology diffusion, and Diaspora communication channels. On contrary the positive impact is low in the high-income countries due to the migration of intellectuals, talents or high skilled individuals represent a significant loss in the human capital which represents the backbone of the economic growth in these countries.

Table (10): Brain drain and economic growth across regions: Econometrics results

Dependent variables: GDP growth (annual %)
Method:2-way fixed effects model with (White diagonal standard errors)

	Reg (11)	**Reg (12)**	**Reg (13)**	**Reg (14)**	**Reg (15)**	**Reg (16)**
	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	South Asia	Sub-Saharan Africa
Human flight & Brain drain	**1.1021 [2.525]****	**-0.5859 [-1.882]***	**0.8634 [5.654]*****	**-0.4349 [-1.177]**	**-1.5327 [-2.342]****	**0.9045 [4.301]*****
FDI, net inflows	0.0512 [1.481]	-0.0269 [-1.854]*	0.1197 [1.819]*	0.4516 [3.948]***	-0.0550 [-0.249]	-0.0361 [-1.344]
Domestic investment	0.3119 [5.507]***	0.1154 [2.197]**	0.1764 [2.979]***	0.0747 [1.511]	0.2353 [2.249]**	0.0399 [1.542]

Trade openness	0.0341 [1.940]*	0.0724 [4.816]***	0.0384 [3.056]***	-0.0171 [-0.822]	0.1297 [2.949]***	0.0314 [2.365]**
Financial depth	-0.0655 [-2.295]**	-0.0802 [-5.055]***	-0.0786 [-3.287]***	-0.0199 [-0.909]	-0.1267 [-2.293]**	-0.0084 [-0.303]
Human capital	4.0673 [1.207]	2.6626 [0.880]	-0.8432 [-0.368]	1.8384 [0.548]	7.5080 [2.076]**	1.9521 [0.920]
Technical level (TFP_i)	108.39 [2.126]**	124.67 [3.493]***	113.49 [4.358]***	8.4796 [0.233]		18.122 [0.570]
Technical gap (TFP_i/TFP_l)	-102.68 [-2.127]**	-113.34 [-3.260]***	-106.21 [-4.182]***	-6.9145 [-0.206]		-9.9699 [-0.319]
Institutions (WGI)	0.0634 [1.467]	-0.0435 [-0.873]	0.0367 [0.867]	0.1239 [1.534]	0.3414 [2.347]**	0.0849 [3.001]***
Constant	-22.591 [-1.986]*	-10.934 [-1.031]	-8.8966 [-1.174]	-4.0083 [-0.517]	-16.897 [-2.093]**	-17.864 [-3.751]***
Key Regression Statistics						
Obs.	103	192	232	78	66	305
Unit (Countries)	9	17	19	7	6	26
Period	(2007-2019)	(2007-2022)	(2007-2019)	(2007-2019)	(2007-2019)	(2007-2019)
Adjusted R-squared	69.7%	72.2%	67.2%	50.5%	38.8%	55.4%
Fisher test (F-stats.)	(9.3814)***	(20.474)***	(13.454)***	(4.0244)***	(2.7886)***	(9.4052)***

Note: - ***, **, * indicate significance at 1%, 5% and 10% respectively.

The following table (10) shows the relationship between brain drain and economic growth after dividing developing countries into regions. According to the World Bank's division, developing countries have been divided into 6 regions: East Asia & Pacific Europe & Central Asia Latin America & Caribbean Middle East & North Africa South Asia Sub-Saharan Africa.

The results of the previous table (10) indicate that brain drain has positive impact on economic growth in these regions: East Asia & Pacific, Latin America & Caribbean and Sub-Saharan Africa. As brain drain increase by1% the economic growth rate increases by (1.1%, 0.86%, 0.9%) respectively. The positive impact of these regions is due to the deterioration of the economic and political conditions in these regions, in addition to the need of these regions for remittances, which are considered a primary source of foreign exchange necessary to finance their basic needs.

Since the early 2000s, Sub-Saharan Africa's (SSA) significant economic growth has not been adequate to ease the continent's structural financial demands. So migrant remittances represent an important source of income for many families in Sub-Saharan Africa. According to a World Bank dataset, migrant remittances in several countries, including Cabo Verde, the

Democratic Republic of the Congo, Gambia, Lesotho, Liberia, Senegal, and Zimbabwe, surpass 10% of yearly GDP.

Furthermore, Banya and Zajda (2015) states that remittances sent home by migrants to underdeveloped countries are three times the amount of development aid and can have significant implications for development and human wellbeing. On contrary, the results indicates that brain drain has negative impact on economic growth in these regions: Europe & Central Asia and South Asia .as brain drain increase by1% the economic growth rate decreases by(0.59% ,1.5%)respectively. South Asia is among the regions most negatively affected by brain drain. Because most skill immigrants transfer to abroad and they do not return back to their home South Asia is a major source of health-care migration to developed countries. This trend has raised worries that the outflow of health-care professionals is harming developing-country health-care systems, as well as population health and human capital formation. Human capital represents the wealth of these regions and is the main reason for causing a boom in technological progress and raising growth rates. Therefore, the brain drain will certainly negatively affect these regions.

The study uses the following table (11) to answer this question:

Does brain drain lead to increased economic growth through its externalities or Diaspora‘ externalities? So the study used brain drain‘s channels such as human capital, technical level, technical gap and institutions during (2007-2019) at 80 developing countries with 931 observations. Therefore, the study examined the role of moderator variables by establishing interaction variables :(Human flight & Brain drain × Human capital), (Human flight & Brain drain × Technical level), (Human flight & Brain drain × Technical gap), (Human flight & Brain drain ×institutions).to investigate the importance of brain drain and Diaspora externalities.

Table (11): External effects of brain drain and economic growth: Econometrics results

Dependent variables: GDP growth (annual %)
Method:2-way fixed effects model with (White diagonal standard errors)

	Reg (17)	**Reg (18)**	**Reg (19)**	**Reg (20)**
Human flight & Brain drain	**1.4057 [3.056]*** **	**1.9069 [3.025]*** **	**1.4920 [2.509]** **	**0.9565 [3.724]*** **
Human flight & Brain drain × Human capital	**-0.3501 [-1.851]***			
Human flight & Brain drain × Technical level		**-1.3472 [- 2.171]** **		
Human flight & Brain drain × Technical gap			**-0.9045 [-1.583]**	
Human flight & Brain drain ×institutions				**-0.0088 [-1.778]***
FDI, net inflows	0.0206 [1.214]	0.0202 [1.171]	0.0206 [1.181]	0.0222 [1.259]
Domestic investment	0.0762 [4.078]***	0.0764 [3.887]***	0.0741 [3.805]***	0.0719 [3.576]***
Trade openness	0.0409	0.0416	0.0418	0.0395

	[6.509]***	[6.729]***	[6.748]***	[6.333]***
Financial depth	-0.0529 [-5.996]***	-0.0551 [-6.387]***	-0.0554 [-6.446]***	-0.0533 [-6.002]***
Human capital	5.3689 [3.108]***	2.5886 [2.355]**	2.7646 [2.523]**	2.9299 [2.641]***
Technical level (TFP_i)	79.757 [4.321]***	89.558 [4.711]***	81.792 [4.463]***	83.268 [4.448]***
Technical gap (TFP_i/TFP_l)	-70.797 [-3.943]***	-72.807 [-4.060]***	-67.635 [-3.768]***	-74.409 [-4.088]***
Institutions (WGI)	0.0849 [5.051]***	0.0825 [4.917]***	0.0817 [4.858]***	0.1371 [3.743]***
Constant	-24.639 [-5.049]***	-25.542 [-5.151]***	-23.418 [-4.804]***	-20.752 [-5.345]***
Key Regression Statistics				
Obs.	931	931	931	931
Unit (Countries)	80	80	80	80
Period	(2007-2019)	(2007-2019)	(2007-2019)	(2007-2019)
Adjusted R-squared	61.7%	61.9%	61.8%	61.3%
Fisher test (F-stats.)	(15.997)***	(16.136)***	(16.066)***	(15.731)***

Note: - ***, **, * indicate significance at 1%, 5% and 10% respectively.

The results of table (11) shows that using human capital as a moderator or interaction variable (Human flight & Brain drain × Human capital) negatively affected the economic growth at significant level 10%.as (Human flight & Brain drain × Human capital) decrease by 1% the economic growth rate increase by (0.35%) due to the migration of intellectuals which lead to reduce human capital stock the backbone of economic growth . also using technical level as a moderator or interaction variable (Human flight & Brain drain × Technical level) confirm this result .as it negatively affected economic growth at significant level 10%.due to the immigration of intellectuals, talent, academic and professionals from their homeland which reduces the quality of technology which hinder the economic growth.

In addition to the results indicates that the interaction variable (Human flight & Brain drain ×institutions) has a negative impact on economic growth at significant level 10%.as this moderator variable increase by 1% the economic growth rate decrease by 0.0088%. The reason for this is the transfer of cultures that are not compatible with the nature of developing societies, which leads to a slowdown in growth. For example, paying bribes to government agencies speeds up the completion of tasks in most developing countries. Moreover, the presence of migration networks abroad increases the likelihood of the individuals they leave behind migrating, as well as the exposure of residents to foreign norms and values that may conflict with the values and customs of their home country. For example, low fertility rates negatively affect human capital and economic growth.

Briefly the study concluded that brain drain still has a positive impact on economic growth, however the impact of brain drain‘s externalities are negative. This reflects the great importance of remittances, which are excluded from the brain drain ‘externalities due to their

inclusion in the brain drain index. Remittances play an important role in the most developing countries, especially the low-income countries.

5.5 The effect size to determine the scientific significance of the relationship.

The effect sizes give researchers the tools they need to interpret the practical significance of their research results. Using a class-tested approach that includes numerous examples and step-by-step exercises, it introduces and explains three of the most important issues relating to the assessment of practical significance: the reporting and interpretation of effect sizes, the analysis of statistical power, and the meta-analytic pooling of effect size estimates drawn from different studies.

The table (12) shows that the brain drain problem has a small effect, which is consistent with the study findings, because brain drain has a beneficial influence on economic growth in developing countries. The problem for developing countries is not immigration per se, but rather a waste of human resources due to a lack of expenditure on research and development, a lack of appropriate conditions to encourage high-skilled individuals to innovate, a lack of appropriate appreciation, and a lack of appropriate opportunities and wages to encourage migrants to return back to their home. Many countries, including China, India, and Taiwan, reverse brain drain to brain gain.

Table (12): Practical significance for Human flight & Brain drain: Effect Size

	Reg (3)	**Reg (17)**	**Reg (18)**	**Reg (19)**	**Reg (20)**
	Human flight & Brain drain	**Human capital**	**Technical level**	**Technical gap**	**Institutions**
Effect Size (Cohen's d)	0.3811	-0.1289	-0.1512	-0.1100	-0.1238
Effect Size (r)	0.1872	-0.0643	-0.0754	-0.0549	-0.0618
Confidence interval (%95)					
Lower	0.1190	-0.1324	-0.1435	-0.1232	-0.1299
Upper	0.2553	0.0039	-0.0072	0.0132	0.0064
t-stat. (Effect Size)	[5.420]***	[-1.851]*	[-2.171]**	[-1.583]	[-1.778]*
Interpretation	**Small Effect**	**No Effect**	**No Effect**	**No Effect**	**No Effect**

Note: ***, **, * indicate significance at 1%, 5% and 10% respectively.

6. Conclusion

This study contains three models. the first model investigates the direct impact of brain drain on economic growth in the developing countries. The study finds that brain drain is positively affect economic growth and there is a linear relationship between brain and economic growth. this result confirm the immediate impact of remittances which is included in the human flight &brain drain indicator. The study also finds a positive relationship between brain drain and income level. The lower the income, the lower the brain drain. Moreover, by examining the impact of brain drain on economic growth according to regional divisions, the study found a positive impact in some regions, a negative impact in other regions, and no impact in other regions. Due to the differences in institutional, economic, and political structures between regions, Furthermore, the study shows the countries that are most positively affected and the countries that are most negatively affected. The positive and negative impact is due to the economic structure, the failure of institutions, and the strategies and policies the country follows. The second model investigate that there is no dynamic relation between brain drain

and economic growth. that mean brain drain in the previous year does not affect the current economic growth rate . In fact, the emigration of highly skilled workers in the previous year should affect current economic growth, As a result of the loss of intellectual human capital on the one hand and human capital accumulation on the other. But this result confirms the immediate or direct impact of remittances included in the human flight and brain drain indicator. Finally, the third model investigates the indirect impact of brain drain on economic growth through externalities. This model represents the contribution of this study because it establishes moderator or interaction variables such as (human flight and brain drain × human capital), (human flight and brain drain × technical level), (human flight and brain drain × technical gap), and (human flight and brain drain × institutions). These variables are the major paths by which brain drain can impact economic growth. The study revealed that while brain outflow has a favorable influence on economic growth, the externalities of brain drain have a negative impact. This highlights the significance of remittances, which are omitted from the brain drain 'externalities' since they are included in the brain drain index. Most developing countries, particularly low-income ones, rely heavily on remittances. Another contribution to this study is using meta-analysis to determine the size effect and indicate the practical significance of the brain drain problem in developing countries. Given that brain drain has a positive impact on economic growth in developing countries, the issue of brain drain has a small effect, which is in line with the findings of the study. The issue facing developing countries is not migration per se, but rather the waste of human resources resulting from insufficient funding for research and development, an unsuitable environment for highly skilled workers to innovate, insufficient recognition, institutions failure, and an insufficient supply of jobs and business opportunities and Lack of incentives for migrants to return home. Briefly the study's findings indicate a close connection between migration of highly skilled workers and the country's economic growth. In particular, the direct impact of highly educated immigrants on economic growth, as well as the reverse effect of brain drain.

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Appendix

Table (1): Description of the study variables

Variable	Description	Source
Growth	**GDP growth (annual %);** Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars.	(WBI)
Drain	**Human flight and brain drain index;** The Human flight and brain drain indicator considers the economic impact of human displacement (for economic or political reasons) and the consequences this may have on a country’s development. The higher the index, the greater the human displacement.	(FP)
FDI	**Foreign direct investment, net inflows (% of GDP);** Is the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors, and is divided by GDP.	(WBI)
GFCF	**Gross fixed capital formation (% of GDP);** (formerly gross domestic fixed investment) includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings,	(WBI)

and commercial and industrial buildings.

Openness	**Trade (% of GDP);** Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.	(WBI)
Depth	**Domestic credit to private sector (% of GDP);** refers to financial resources provided to the private sector by financial corporations, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment.	(WBI)
HC	**Human capital index;** based on years of schooling and returns to education.	(PWT)
TFP	**Welfare-relevant TFP at constant national prices (2017=1);**total-factor productivity (TFP), also called multi-factor productivity, is usually measured as the ratio of aggregate output (e.g., GDP) to aggregate inputs. Under some simplifying assumptions about the production technology, growth in TFP becomes the portion of growth in output not explained by growth in traditionally measured inputs of labour and capital used in production. Total factor productivity is a measure of technical progress.	(PWT)
TFP gap	**Technical gap;**The difference in technologies used and/or developed in two countries where one is more advanced than the other. It is calculated by the researcher by dividing the TFP of the country by the TFP of the USA, which represents the global technological frontier.	(Author)
WGI	**World Governance Indicator;**The WGI project reports aggregate and individual governance indicators for over 200 countries and territories for six dimensions of governance: Voice and Accountability; Political Stability and Absence of Violence/Terrorism; Government Effectiveness; Regulatory Quality; Rule of Law; Control of Corruption.	(WBI)

Sources: - **WBI**: World Bank Indicators; - **FP**: Fund for Peace; - **PWT**: Penn World Table 10.0.