Dynamic Relationship between Migration, Unemployment, and Economic Growth in Morocco: Evidence from Cointegration and VECM Analysis

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Absract. This study investigates the dynamic relationships between net migration, the unemployment rate, and GDP per capita in Morocco using a Vector Error Correction Model (VECM) with annual data from 1991 to 2024. The research aims to fill a notable gap in the existing literature by examining the long-run equilibrium relationships and short-run dynamics among these key macroeconomic variables. Our findings reveal that all three variables are integrated of order one, I(1), and share a single, stable long-run equilibrium relationship. The long-run analysis demonstrates that net migration has a significant and positive effect on GDP per capita, while the unemployment rate has a negative effect. These results are consistent with established economic theories, such as the "migration-led growth" hypothesis and Okun's Law. The short-run dynamics indicate that GDP per capita actively adjusts to restore equilibrium following a shock, while both net migration and unemployment appear to be weakly exogenous, responding very little to short-run deviations from the long-run path. This suggests that migration flows and labor market dynamics in Morocco are primarily driven by their own inertia and factors external to the immediate economic system. In conclusion, this paper provides robust empirical evidence that net migration plays a vital and positive role in Morocco's long-term economic growth, while high unemployment acts as a persistent drag on per-capita output. The findings offer important policy implications for fostering sustainable economic development through well-managed migration and targeted employment strategies.

Keywords: *Net Migration; Unemployment Rate; GDP per Capita; Cointegration relation; Vector Error Correction Model (VECM).*

1. Introduction

Morocco, like many emerging economies, faces significant challenges and opportunities related to labor market dynamics and migration flows. Net migration, the difference between immigration and emigration, has become a crucial determinant of the country's demographic structure, labor force composition, and overall economic performance. Morocco has experienced both emigration of skilled workers seeking better opportunities abroad and immigration inflows, particularly from neighboring countries and sub-Saharan Africa. These movements influence the size and quality of the labor force, domestic consumption, investment patterns, and ultimately GDP per capita. At the same time, unemployment remains a persistent structural challenge, with youth and urban unemployment rates often exceeding national averages, affecting household incomes and limiting economic growth.

Economic theory suggests that net migration and unemployment exert contrasting effects on economic growth. Net migration can stimulate GDP per capita by expanding the labor supply, enhancing human capital, and fostering productivity gains. Conversely, high unemployment reflects underutilized labor resources, reducing output and economic efficiency, consistent with Okun's Law (Okun, 1962). Empirical evidence for Morocco is limited, particularly regarding the dynamic interactions between migration, unemployment, and per-capita output. Most existing studies focus separately on migration or labor market issues, often neglecting their joint long- and short-run effects on economic performance.

This study aims to fill this gap by investigating the long- and short-run relationships between net migration, unemployment, and GDP per capita in Morocco. Using annual data from 1991 to 2024, the analysis employs the Johansen cointegration test to identify long-run equilibrium relationships and a Vector Error Correction Model (VECM) to capture short-run dynamics and adjustments to deviations from equilibrium. This approach allows for a comprehensive understanding of how labor mobility and labor market conditions jointly influence Morocco's economic performance.

The study makes two main contributions. First, it provides empirical evidence on the role of migration in promoting per-capita economic growth in Morocco, highlighting the potential benefits of well-managed migration policies. Second, by modeling both long-run equilibria and short-run dynamics, it identifies how GDP per capita, migration flows, and unemployment adjust to shocks over time, offering insights for policymakers seeking to balance labor market efficiency with sustainable economic growth. The results have important implications for designing migration and employment policies that maximize economic benefits while mitigating labor market distortions.

The remainder of this paper is structured as follows: Section 2 presents the literature review. Section 3 describes the data and the methodology employed. Section 4 reports and discusses the empirical results. Finally, Section 5 concludes by highlighting the main implications.

2. Literature review

The relationship between migration and a country's economic performance, particularly its GDP per capita, is a central theme in modern economic literature. The body of work on this topic reveals a complex interplay of factors, often leading to a varied impact depending on the specific economic context and the nature of the migration flow. This review synthesizes key findings from several recent studies on this topic.

A significant portion of the literature supports the view that immigration has a net positive impact on the economic growth of receiving countries. Research by Jaumotte et al (2016) on advanced economies finds that immigration increases GDP per capita primarily by enhancing labor productivity. They estimate that a one percentage point increase in the share of migrants can raise a host country's GDP per capita by up to 2 percent in the long run. This positive effect is attributed to both high- and low-skilled migrants, who complement the existing skill sets of the native-born population. This finding is reinforced by Boubtane et al (2016), who, in a study of 22 OECD countries, identify a positive impact of migrants' human capital on GDP per capita and productivity growth. The study by Dritsaki and Dritsaki (2021) on EU nations also supports a significant positive correlation between net migration and GDP per capita, finding a long-term causal relationship between economic growth and migration.

While many studies find a positive relationship, other research highlights the complexity and conditional nature of this effect. The study by Afzal and Kalra (2024) on selected OECD countries suggests that the benefits of skilled immigration are not automatic. Their findings indicate that while non-residential patent applications and R&D expenditure are strongly linked to GDP productivity, residential patent applications show an adverse effect. This implies that host countries must invest in a knowledge-based economy to fully benefit from skilled immigration. Similarly, the research by Rayevnyeva et al (2023), while confirming a positive effect of general migration on GDP, also identifies a negative effect on the active population, suggesting a more nuanced relationship.

The economic impact can also vary significantly based on the country and type of migration. Touhami and Kharkhach (2019), for example, found that in the specific context of Morocco, Sub-Saharan immigration had a negative impact on GDP per capita between 2000 and 2018. This contrasts with the positive findings for developed nations and underscores the importance of country-specific analysis. Additionally, Seyhan and Seyhan (2024) demonstrate the bidirectional nature of the relationship, finding that while migration influences macroeconomic variables, economic factors such as unemployment also significantly affect migration patterns.

In conclusion, the literature confirms that migration is a powerful force influencing macroeconomic variables. While there is a consensus on the positive impact of immigration on the GDP of advanced economies, these benefits are not guaranteed and depend on factors such as the migrants' human capital, the host country's ability to integrate them, and its specific economic policies. The literature also recognizes the significant role of remittances in countries with high emigration rates, a key factor that can counterbalance the potential negative effects of population outflow.

3. Data and Methodology

a. Data

The analysis focuses on three macroeconomic variables, GDP per capita, net migration rate, and unemployment rate, chosen to capture the main interactions between migration, labor market performance, and economic growth. GDP per capita serves as a proxy for economic well-being, the net migration rate reflects labor mobility and demographic dynamics, and the unemployment rate represents labor market efficiency. The inclusion of these variables is consistent with the “migration-led growth” hypothesis and Okun’s Law, which emphasize the reciprocal links between migration, employment, and output growth.

This study uses annual data covering the period 1991–2024. This period was carefully chosen to ensure both the availability of consistent and reliable annual data and the relevance of the long-term dynamics under investigation. This time frame captures more than three decades of Morocco’s economic, social, and institutional evolution, encompassing major policy reforms, structural adjustment programs, and globalization-driven transformations that have significantly influenced migration flows, labor market conditions, and overall economic performance.

The analysis focuses on three key macroeconomic variables:

- GDP per Capita (GDPC), measured in constant U.S. dollars (USD) per person, captures the average economic output per individual and serves as a proxy for economic well-being.
- Net Migration Rate (NMR) refers to the difference between the number of immigrants (people entering a country) and the number of emigrants (people leaving a country) throughout a given year, expressed per 1000 inhabitants of the mid-year population. A positive rate indicates a net inflow of migrants (more people entering than leaving), while a negative rate indicates a net outflow (more people leaving than entering). In formal terms:

$$NMR = 1000 \times \frac{Immigrants - Emigrants}{Mid\ year\ population} \quad (1)$$

- Unemployment Rate (UR) is the proportion of the labor force that is without work but actively seeking employment. It reflects the efficiency of the labor market and indicates potential losses in economic output.

Data sources of GDP per Capita, Unemployment rate and (Immigrants-Emigrants) include the World Bank Open Data platform (https://data.worldbank.org) and the Macrotrend platform (https://www.macrotrends.net).

The Mid-year population is typically calculated from population data at the beginning and end of a year:

$$Mid\ year\ Population(t) = \frac{Population(t) + Population(t-1)}{2} \quad (2)$$

The GDPC, NMR, and UR series are plotted in Figure 1.

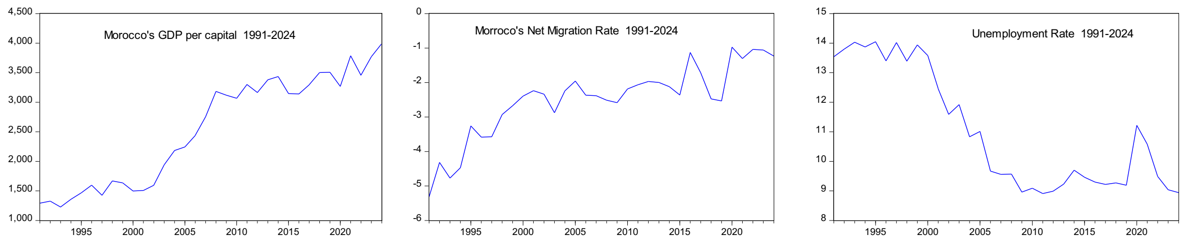

Figure 1: Plots of GDPC, NMR, and UR from 1991 to 2024

b. Methodology

Given the time series nature of the data, the study employs a Vector Error Correction Model (VECM). The Vector Error Correction Model (VECM) was selected because it appropriately handles non-stationary but cointegrated time series. The variables, GDP per capita, net migration rate, and unemployment rate; are all integrated of order one and exhibit a long-run equilibrium relationship, as confirmed by the Johansen cointegration test. The VECM captures both long-term relationships and short-term adjustments, providing insights into how deviations from equilibrium are corrected over time. This makes it particularly suitable for examining the dynamic interplay among migration, employment, and economic growth.

The methodology follows several key steps:

1) Unit Root Tests

Before modeling, it is essential to verify the stationarity properties of the series. The Augmented Dickey-Fuller (ADF) test was applied to each variable.

2) Johansen Cointegration Test and VECM

To examine whether a long-run equilibrium relationship exists among GDP per capita (GDPC), Net Migration Rate (NMR), and Unemployment Rate (UR), the Johansen cointegration test was employed. This method, introduced by Johansen (1988), is based on a Vector Autoregressive (VAR) model (Sims, 1980) and allows the identification of one or more cointegrating vectors, indicating a stable long-term relationship among the variables.

The Johansen procedure starts from a $VAR(p)$ model:

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + \cdots + A_p X_{t-p} + \varepsilon_t \tag{3}$$

where X_t is an 3×1 vector of $I(1)$ variables $(GDP_t\ NMR_t\ UR_t)$, A_i are coefficient matrices, and ε_t is a vector of white noise errors.

The VAR model can be rewritten in Vector Error Correction Model (VECM) form (Johansen, 1988; Johansen and Juselius, 1990; Johansen 1995):

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i . \Delta X_{t-i} + \varepsilon_t \tag{4}$$

where:

- Δ denotes first difference,
- Π is the long-run impact matrix, whose rank determines the number of cointegrating relationships,
- Γ_i are short-run coefficient matrices.

If the rank of Π is r $(0 < r < 3)$, then there are r cointegrating vectors, and Π can be decomposed as:

$$\Pi = \alpha\beta' \tag{5}$$

where:

- β $(3 \times r)$ contains the cointegrating vectors, representing long-run relationships among the variables,

- α $(3 \times r)$ contains the adjustment coefficients, indicating the speed at which variables return to equilibrium after a shock.

The trace test and maximum eigenvalue test are used to determine the number of cointegrating vectors:

The Trace statistic is defined by:

$$Trace = -T.\sum_{i=r+1}^{3} ln(1-\lambda_i) \tag{6}$$

The Maximum eigenvalue statistic is defined by:

$$Max - Eigen = -T.ln(1-\lambda_{r+1}) \tag{7}$$

where λ_i are the estimated eigenvalues and T is the sample size.

Running the* Johansen Cointegration Test*:

For the three variables ($n = 3$), the test will sequentially evaluate the following null hypotheses:

- H_0: $r = 0$ (no cointegrating vectors)
- H_0:$r \leq 1$ (at most one cointegrating vector)
- H_0:$r \leq 2$ (at most two cointegrating vectors)

We continue to reject the null hypothesis as long as the test statistic is greater than the critical value. The first null hypothesis we fail to reject determines the number of cointegrating vectors. For example, if we reject H_0: $r = 0$ but fail to reject H_0:$r \leq 1$, it means we have one cointegrating vector ($r = 1$). This confirms that a long-run equilibrium relationship exists, justifying the use of a VECM.

Estimating and Interpreting the VECM

Once we've confirmed cointegration, we estimate a VECM with the cointegrating rank determined in the previous step. The model for our three variables would look like this:

$$\begin{pmatrix} \Delta GDPC_t \\ \Delta NMR_t \\ \Delta UR_t \end{pmatrix} = \alpha(\beta_{11} \quad \beta_{12} \quad \beta_{13}) \begin{pmatrix} GDPC_{t-1} \\ NMR_{t-1} \\ UR_{t-1} \end{pmatrix} + \Gamma_1 . \begin{pmatrix} \Delta GDPC_{t-1} \\ \Delta NMR_{t-1} \\ \Delta UR_{t-1} \end{pmatrix} + \sum_{i=2}^{p-1} \Gamma_i . \begin{pmatrix} \Delta GDPC_{t-i} \\ \Delta NMR_{t-i} \\ \Delta UR_{t-i} \end{pmatrix} + \varepsilon_t \tag{8}$$

- Long-Run Equilibrium (β'): The coefficients in the cointegrating vector, $\beta' = (\beta_{11} \quad \beta_{12} \quad \beta_{13})$, show the long-run relationship. For instance, if we found one cointegrating vector ($r = 1$), the equation $\beta_{11}.GDPC_{t-1} + \beta_{12}.NMR_{t-1} + \beta_{13}.UR_{t-1} = 0$ represents the long-run equilibrium. We would normalize one of the coefficients (e.g., set $\beta_{11} = 1$) to interpret the long-run effect of NMR and UR on $GDPC$.
- Speed of Adjustment (α): The coefficients in the α matrix indicate how each of the three variables responds to correct for a deviation from the long-run equilibrium. For example, if the coefficient in the first row of α is significant and negative, it means that $GDPC$ adjusts to bring the system back to equilibrium after a shock. A large absolute value suggests a rapid adjustment.
- Short-Run Dynamics (Γ_i**):** The Γ matrices capture the short-term interactions between the variables' first differences. The coefficients here can show, for instance, how a change in NMR in the previous period affects the current change in UR.

3) Impulse Response Functions (IRFs)

To further understand the dynamic interactions, Impulse Response Functions (Sims, 1980) are computed. After estimating the VECM, we can use IRFs to visualize the dynamic impact of a one-standard-deviation shock to one of the variables on all three variables over time. For the three variables (GDPC, NMR, UR), we would have a set of nine IRF plots. For example:

- Shock to GDPC: We would analyze three plots: how GDPC responds to a GDPC shock, how NMR responds to a GDPC shock, and how UR responds to a GDPC shock.
- Shock to NMR: We would analyze three plots: how GDPC responds to an NMR shock, how NMR responds to an NMR shock, and how UR responds to an NMR shock.
- Shock to UR**:** We would analyze three plots: how GDPC responds to a UR shock, how NMR responds to a UR shock, and how UR responds to a UR shock.

Since the variables are cointegrated, the IRFs may not die out completely to zero. Instead, they might converge to a new, non-zero constant, indicating that the shock has a permanent effect on the level of the variables.

4) Variance Decomposition (VDC)

Variance Decomposition (VDC) is a forecasting tool used to determine the proportion of the forecast error variance in each variable that can be attributed to shocks in the other variables in the model. In a Vector Error Correction Model (VECM), after we've run the Impulse Response Functions, VDC helps us understand the relative importance of each variable's shocks in explaining the fluctuations of all other variables over time.

How It Works: VDC provides a breakdown of the total forecast error variance for a given variable at different time horizons. For instance, for the variables (GDPC, NMR, UR), the VDC would tell us:

- For GDPC: What percentage of the forecast error variance in GDPC at a 10-period horizon is due to its own shocks, and what percentages are due to shocks in NMR and UR?
- For NMR: What percentage of its forecast error variance is explained by shocks to GDPC, its own shocks, and shocks to UR?
- For UR: What percentage of its forecast error variance is explained by shocks to GDPC, NMR, and its own shocks?

A large percentage attributed to another variable's shock indicates that the first variable is highly responsive to shocks originating from the second.

4. Results

a. Results of Stationarity Test (ADF)

The stationarity of the Net Migration Rate (NMR), GDP per capita (GDPC), and Unemployment Rate (UR) series was examined using the Augmented Dickey-Fuller (ADF) test. The results are summarized in table 1.

Table 1: Results of the ADF test

NMR (at level)	D(NMR) (1st difference)	GDPC (at level)	D(GDPC) (1st difference)	UR (at level)	D(UR) (1st difference)
-1.937401	-6.485282	-0.278551	-4.468168	-1.092657	-3.989743

The critical values are given in table 2.

Table 2: Critical values for the ADF test

Test critical values	
1% level	-3.653730

5% level	-2.957110
10% level	-2.617434

The results indicate that all three variables are non-stationary at their level forms, as their ADF test statistics (-1.937 for NMR, -0.279 for GDPC, and -1.093 for UR) are higher than the critical values at the 1%, 5%, and 10% significance levels. This implies that the null hypothesis of a unit root cannot be rejected at levels, confirming non-stationarity. However, after applying the first difference, each series becomes stationary. The ADF statistics for the first-differenced series (D(NMR) = -6.485, D(GDPC) = -4.468, D(UR) = -3.990) are all below the critical values, leading to the rejection of the null hypothesis.

We conclude that NMR, GDPC, and UR are all integrated of order one, $I(1)$. This finding justifies the use of cointegration analysis to investigate potential long-run relationships among these variables.

b. Results of the Johansen Cointegration test

To examine the existence of a long-run equilibrium relationship among Net Migration Rate (NMR), GDP per capita (GDPC), and Unemployment Rate (UR), the Johansen cointegration test is applied. This test allows for the identification of one or more cointegrating vectors, indicating whether the variables share a stable long-term relationship despite being individually non-stationary. The results of the test are presented in Table 3.

Table 3: Results of Johansen cointegration test

Sample (adjusted): 1993 2024

Included observations: 32 after adjustments

Trend assumption: Linear deterministic trend

Series: GDPC NMR UR

Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.464837	30.77940	29.79707	0.0384
At most 1	0.262843	10.77351	15.49471	0.2258
At most 2	0.031220	1.014972	3.841465	0.3137

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.464837	20.00589	21.13162	0.0713
At most 1	0.262843	9.758536	14.26460	0.2283
At most 2	0.031220	1.014972	3.841465	0.3137

Max-eigenvalue test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

GDPC	NMR	UR
0.002710	-1.668998	0.567666

1 Cointegrating Equation(s): Log likelihood -253.2850

Normalized cointegrating coefficients (standard error in parentheses)

GDPC	NMR	UR

	-0.001567	-0.724057	-1.231478
	0.001491	0.336267	0.317155

Unrestricted Adjustment Coefficients (alpha):

D(GDPC)	-106.4211	45.84761	-13.05295
D(NMR)	0.229195	-0.024138	-0.061545
D(UR)	0.278481	0.240260	0.013794

2 Cointegrating Equation(s): Log likelihood -248.4058

Normalized cointegrating coefficients (standard error in parentheses)

GDPC	NMR	UR
1.000000	0.000000	538.6666
		(64.8622)
0.000000	1.000000	0.534683
		(0.10823)

Adjustment coefficients (standard error in parentheses)

D(GDPC)	-0.360318	144.4204
	(0.09411)	(54.6813)
D(NMR)	0.000659	-0.365049
	(0.00026)	(0.14996)
D(UR)	0.000378	-0.638747
	(0.00031)	(0.17759)

1.000000	-615.7549	209.4328
	(125.865)	(61.2977)

Adjustment coefficients (standard error in parentheses)

D(GDPC)	-0.288454
	(0.08491)
D(NMR)	0.000621
	(0.00022)
D(UR)	0.000755
	(0.00029)

Cointegration Rank Results

a) Trace Statistic

The Trace test evaluates the null hypothesis that the number of cointegrating vectors r is less than or equal to a given value. The results are as follows:

- $H_0: r = 0$ (no cointegration) → Trace statistic = 30.77, which exceeds the 5% critical value of 29.79. Therefore, the null hypothesis is rejected, suggesting that at least one cointegrating relationship exists.
- $H_0: r \leq 1$ → Trace statistic = 10.77, which is below the 5% critical value of 15.49. Hence, the null hypothesis is not rejected, indicating no more than one cointegrating vector.

We deduce that the Trace test supports the presence of one long-run equilibrium relationship among the three variables.

b) Maximum Eigenvalue Statistic

The Maximum Eigenvalue test examines the null hypothesis that the number of cointegrating vectors is exactly r against the alternative of $r + 1$. The results are as follows:

- $H_0: r = 0$ → Max-Eigen statistic = 20.01 < 21.13 (5% critical value) → fail to reject H_0.
- $H_0: r \leq 1$ → Max-Eigen statistic = 9.76 < 14.26 (5% critical value) → fail to reject H_0.

Thus, the Max-Eigenvalue test does not indicate a cointegration relationship. However, in small samples, the Trace test is generally considered more robust and reliable than the Maximum Eigenvalue test (Johansen & Juselius, 1990). Considering the Trace statistic and the small sample context, the analysis supports the existence of one cointegrating vector ($r = 1$) among NMR, GDPC, and UR. This result implies that these three macroeconomic variables share a stable long-run relationship, despite short-term fluctuations.

Long-Run Relationship

From the normalized cointegration vector ($r = 1$) given in table 3, we deduce the long-run relationship:

$$GDPC = 615.75\, NMR - 209.43\, UR \tag{9}$$

(Std. errors: $NMR = 125.86$, $UR = 61.29$ → both significant)

The long-run coefficients from the cointegration analysis indicate that Net Migration Rate (NMR) has a positive effect on GDP per capita, with a coefficient of 615.75. This suggests that higher net migration inflows are associated with increased GDP per capita. The result is intuitive: migration can expand the labor force, boost domestic demand, and facilitate the transfer of skills and remittances that support economic growth. This finding is consistent with the "migration-led growth" hypothesis commonly observed in developing economies.

In contrast, the Unemployment Rate (UR) coefficient is negative (-209.43), indicating that higher unemployment reduces GDP per capita. This outcome reflects the underutilization of human capital and the associated decline in productivity.

We conclude that the long-run equilibrium relationship shows that migration positively contributes to economic growth, while unemployment exerts a negative effect on GDP per capita, highlighting the contrasting roles of labor inflows and labor underutilization in the Moroccan economy.

Short-Run Dynamics (Error-Correction Adjustment, α)

The error-correction coefficients provide insights into how each variable responds to deviations from the long-run equilibrium, indicating both the speed and direction of adjustment toward the long-run relationship.

For GDP per capita (D(GDPC)), the error-correction coefficient is -0.288, which is significant and negative. This implies that approximately 28.8% of any deviation from the long-run equilibrium is corrected within one year. In other words, GDP per capita adjusts relatively quickly toward its long-run path, demonstrating a strong response to disequilibrium. This reflects the endogenous role of GDP in the system, as it moves back toward balance whenever it deviates from its equilibrium relationship with migration and unemployment.

In contrast, the coefficient for Net Migration Rate (D(NMR)) is very small (0.00062) and likely insignificant. This near-zero value indicates that net migration responds very little to deviations from the long-run equilibrium. Therefore, migration appears to be weakly exogenous in this model: it influences GDP but does not adjust substantially to restore equilibrium in the short run.

Similarly, the Unemployment Rate (D(UR)) has a small error-correction coefficient (0.00075), suggesting minimal adjustment to disequilibrium. While unemployment exerts a long-run influence on GDP, it does not significantly react to short-run deviations from the equilibrium, highlighting its role as a long-run driver rather than a short-run adjuster.

The short-run dynamics further suggest that GDP per capita is the main variable adjusting to restore long-run balance, while migration and unemployment behave as external drivers of growth. This implies that policies targeting labor market efficiency and migration management can have lasting effects on economic performance.

From a policy perspective, these findings underline the importance of creating an environment that leverages the benefits of migration while addressing structural unemployment. Policies that encourage the integration of migrants into the labor market, invest in human capital, and reduce barriers to employment would not only support economic stability but also enhance long-term growth prospects.

c. Results of VECM

To examine both the short-run dynamics and long-run relationships among Net Migration Rate (NMR), GDP per capita (GDPC), and Unemployment Rate (UR), the Vector Error Correction Model (VECM) was estimated. The VECM allows for the identification of how variables adjust in the short term to restore deviations from the long-run equilibrium, as well as the magnitude and direction of long-run relationships. The results, including error-correction coefficients and short-run dynamics, are presented and interpreted in the table below.

Table 4: Results of Vector Error Correction Model

Vector Error Correction Estimates

Sample (adjusted): 1994 2024

Included observations: 31 after adjustments

Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
GDPC(-1)	1.000000
NMR(-1)	-875.2873
	(253.605)
	[-3.45139]
UR(-1)	199.9102
	(119.469)
	[1.67332]
C	-6857.312

Error Correction:	D(GDPC)	D(NMR)	D(UR)
CointEq1	-0.072399	0.000449	0.000524
	(0.07346)	(0.00017)	(0.00028)
	[-0.98561]	[2.57905]	[1.86620]
D(GDPC(-1))	-0.160470	-0.000600	-0.000205
	(0.16467)	(0.00039)	(0.00063)
	[-0.97449]	[-1.53571]	[-0.32492]
D(GDPC(-2))	-0.162762	-0.000252	-0.000423
	(0.16974)	(0.00040)	(0.00065)
	[-0.95892]	[-0.62583]	[-0.65128]
D(NMR(-1))	23.97591	-0.149614	0.069805
	(77.1196)	(0.18285)	(0.29485)
	[0.31089]	[-0.81824]	[0.23675]
D(NMR(-2))	-21.66139	-0.427519	-0.352630
	(64.5984)	(0.15316)	(0.24697)
	[-0.33532]	[-2.79131]	[-1.42780]
D(UR(-1))	18.87851	-0.122216	-0.343955
	(57.9634)	(0.13743)	(0.22161)
	[0.32570]	[-0.88930]	[-1.55209]

D(UR(-2))	-170.5703	0.188069	-0.077517
	(57.7757)	(0.13698)	(0.22089)
	[-2.95228]	[1.37293]	[-0.35093]
C	94.35108	0.259515	-0.140195
	(43.1835)	(0.10239)	(0.16510)
	[2.18489]	[2.53465]	[-0.84915]

VECM Interpretation

A) Long-Run Relationship (Cointegration Equation)

The cointegrating equation (normalized on GDPC) is :

$$GDPC_{t-1} - 875.2873NMR_{t-1} + 199.9102 - 6857.312 = 0 \quad (10)$$

Rewriting to show the ctual long-run effects:

$$GDPC_{t-1} = 6857.312 + 875.2873NMR_{t-1} - 199.9102 \quad (11)$$

The results indicate that the Net Migration Rate (NMR) has a positive and statistically significant coefficient of 875.2873 ($t = 3.45$). This suggests that, in the long run, higher net migration inflows are associated with higher GDP per capita. Economically, this aligns with endogenous growth theories, which posit that migration can expand the labor force, enhance human capital, and increase productivity, all of which contribute to higher per-capita output.

In contrast, the Unemployment Rate (UR) exhibits a negative coefficient of -199.9102 ($t = 1.67$), indicating that higher unemployment reduces GDP per capita. While this effect is weakly significant, it is consistent with Okun's Law, which predicts a negative relationship between unemployment and output. The weak significance implies that other factors in the economy may mitigate the impact of unemployment on long-run GDP.

Finally, the constant term (6857.312) represents the baseline GDP per capita when both NMR and UR are zero.

B) Error Correction Term (ECT)

The error-correction term (ECT) measures how each variable adjusts to restore deviations from the long-run equilibrium, reflecting the speed and significance of short-run corrections.

- For GDP per capita (ΔGDPC), the ECT coefficient is -0.0724 with a t-statistic of -0.986. This indicates that GDP adjusts slowly toward the long-run equilibrium, correcting about 7.2% of any disequilibrium per period. However, the adjustment is not statistically significant, suggesting that GDP responds only weakly in the short run.
- For Net Migration Rate (ΔNMR), the ECT coefficient is 0.000449 with a t-statistic of 2.579. This positive and significant value implies that net migration adjusts meaningfully to restore the long-run equilibrium, actively contributing to the correction process.
- For Unemployment Rate (ΔUR), the ECT coefficient is 0.000524 with a t-statistic of 1.866. This shows a weak adjustment toward equilibrium, indicating that unemployment responds modestly to short-term deviations but still plays a role in the system's return to long-run balance.

Overall, these results suggest that while GDP per capita adjusts slowly and insignificantly, migration plays a more significant role in correcting disequilibrium, and unemployment contributes modestly to restoring the long-run equilibrium among the variables.

C) Short-Run Dynamics

The short-run behavior of the system is captured by the VECM equations, highlighting how each variable responds to past shocks:

- ΔGDPC equation: The analysis shows a significant impact of past unemployment on current GDP per capita. Specifically, ΔUR(-2) has a coefficient of -170.57 ($t = -2.95$), indicating that unemployment shocks from two periods ago reduce GDP per capita today. Other lags of GDPC and NMR are statistically insignificant, suggesting that in the short run, fluctuations in GDP per capita are primarily driven by past unemployment rather than its own past values or past migration changes.
- ΔNMR equation: The coefficient of ΔNMR(-2) is -0.4275 ($t = -2.79$), which is significant. This result indicates that past changes in net migration negatively affect current changes, reflecting a self-correcting mechanism in the migration series over the short run.
- ΔUR equation: Most of the coefficients in the unemployment equation are insignificant, implying that short-run dynamics of unemployment are weakly influenced by past shocks. In other words, unemployment does not respond strongly to recent deviations in GDP or migration in the short term.

Overall, these findings suggest that short-run fluctuations in GDP are mainly driven by lagged unemployment shocks, net migration exhibits self-correction, and unemployment responds only weakly to past changes in the system.

d. Impulse response functions

To further analyze the dynamic interactions among GDP per capita (GDPC), Net Migration Rate (NMR), and Unemployment Rate (UR), impulse response functions (IRFs) was employed. The impulse response analysis traces the effect of a one-time shock to one variable on the current and future values of all variables in the system, providing insights into the magnitude, direction, and persistence of these effects.

The table below presents the impulse response functions (IRFs) of GDP per capita (GDPC), Net Migration Rate (NMR), and Unemployment Rate (UR) over a 10-period horizon, based on a Cholesky ordering of GDPC → NMR → UR. These responses illustrate how each variable reacts over time to a one-standard-deviation shock in itself and in the other variables.

Table 5: Results of the impulse response functions

Response of GDPC:			
Period	GDPC	NMR	UR
1	166.0332	0.000000	0.000000
2	120.0120	33.51640	2.733238
3	114.3153	30.97457	-115.1247
4	95.94325	46.23296	-54.01470
5	93.21529	90.59672	-57.29243
6	80.99382	59.63216	-60.91138
7	82.21934	51.04637	-47.49030
8	82.29123	75.05105	-49.83720
9	77.59538	71.20549	-57.87318

10	76.63832	62.49690	-50.81811

Response of NMR:

Period	GDPC	NMR	UR
1	-0.077824	0.385890	0.000000
2	-0.056439	0.177836	-0.020116
3	-0.003482	-0.038385	0.167603
4	0.066510	0.068426	0.112988
5	0.066904	0.057511	0.026178
6	0.077189	-0.000948	0.049307
7	0.095140	0.032651	0.068414
8	0.097344	0.033717	0.042023
9	0.099335	0.002002	0.045230
10	0.106735	0.013576	0.053557

Response of UR:

Period	GDPC	NMR	UR
1	-0.127041	-0.042999	0.620452
2	-0.013333	-0.182800	0.472051
3	0.012974	-0.372004	0.533154
4	0.074752	-0.256595	0.485430
5	0.071446	-0.234012	0.435130
6	0.077112	-0.308096	0.447727
7	0.094770	-0.297605	0.474012
8	0.100174	-0.277073	0.449347
9	0.099207	-0.303166	0.443703
10	0.104906	-0.303094	0.455130

Cholesky Ordering: GDPC NMR UR

Interpretation

Response of GDPC:

- GDPC reacts strongly to its own shock, with an initial response of 166.03 in period 1, gradually declining over time but remaining positive, indicating persistent effects of GDP shocks on itself.
- Shocks in NMR have a growing positive impact on GDPC over the horizon, peaking around periods 5–8 (up to 90.60), which highlights that net migration positively influences GDP per capita with some lag, likely reflecting labor force expansion, skill transfers, and remittances.
- UR shocks have a negative impact on GDPC throughout the period, with the largest negative response in period 3 (-115.12), suggesting that higher unemployment significantly reduces GDP in the short and medium run.

Response of NMR:

- NMR shows an initial positive response to its own shock (0.39 in period 1) but fluctuates over subsequent periods, indicating partial self-correction in migration flows.
- GDP shocks have minimal impact on NMR, suggesting that GDP per capita does not strongly drive short-term changes in net migration.
- UR shocks slightly influence NMR, with positive and negative variations, indicating weak short-run interactions between unemployment and migration.

Response of UR:

- UR responds strongly to its own shock initially (0.62 in period 1) and remains persistent across periods, reflecting high inertia and persistence in unemployment dynamics.
- Shocks in GDPC initially reduce UR (-0.13) but later slightly increase it, suggesting GDP shocks have a modest but mixed effect on unemployment.
- NMR shocks consistently reduce UR over time (-0.37 by period 3), indicating that higher net migration tends to lower unemployment, likely through labor market absorption of migrants.

Overall, the IRFs confirm that migration plays a supportive role in GDP growth, unemployment has a dampening effect, and short-term dynamics reflect both persistence and delayed responses among the variables.

The results of the IRFs can be represented in the multiple graphs displayed in Figure 2.

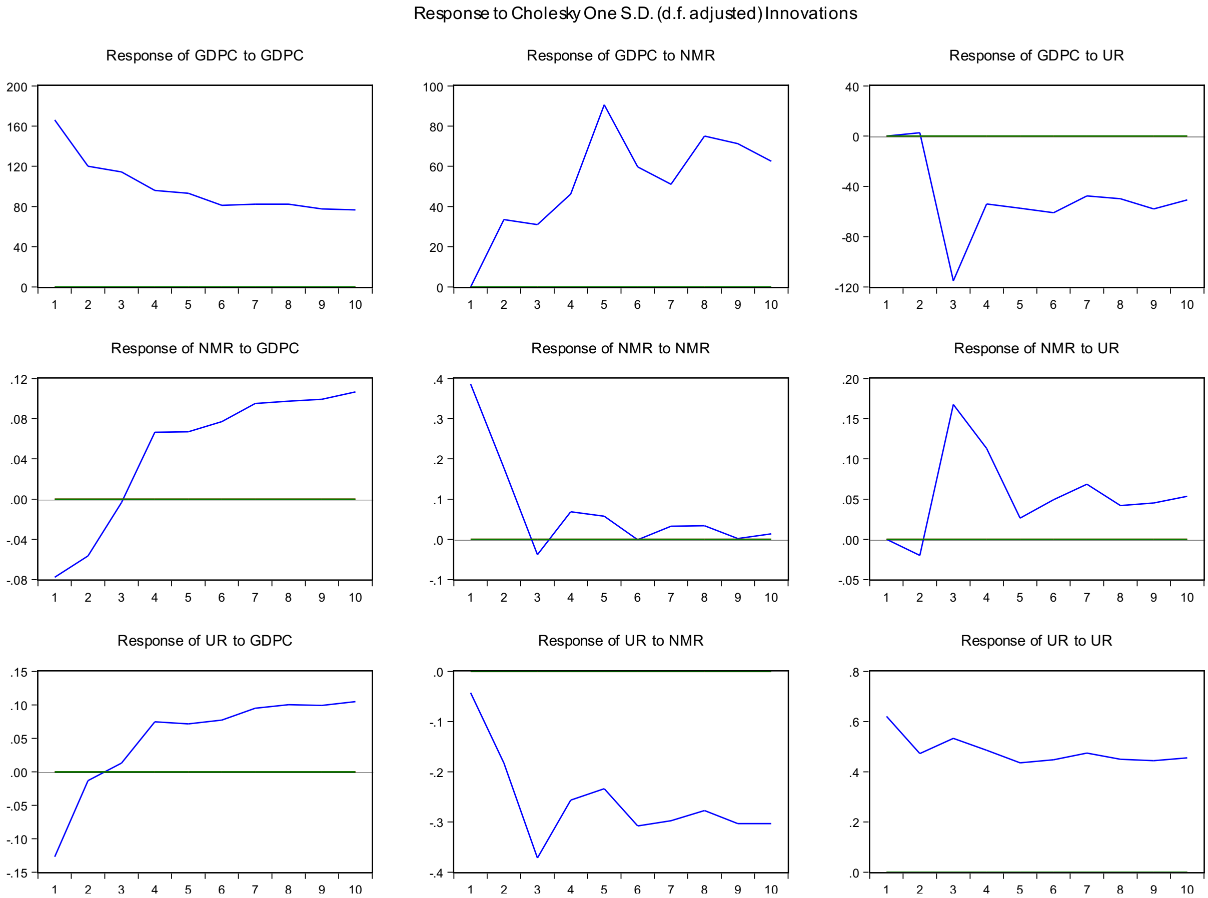

Figure 2: Multiple graphs of impulse responses

Interpretation of Multiple Impulse Response Graphs

Response of GDPC (GDP per capita):

- GDPC to GDPC: The first graph (top-left) shows that a shock to GDP itself initially increases GDP sharply, then gradually declines and stabilizes over 10 periods. This indicates that GDP has a self-correcting behavior but retains some persistence from its own past shocks.
- GDPC to NMR: The middle-top graph shows that a positive shock in net migration significantly increases GDP over the next few periods, peaking around periods 4–5, then slightly declining but remaining positive. This confirms the positive contribution of migration to economic growth.
- GDPC to UR: The top-right graph shows that a positive shock in unemployment causes GDP to fall sharply in the first period, then partially recovers, reflecting the negative effect of higher unemployment on output.

Response of NMR (Net Migration Rate):

- NMR to GDPC: The left-middle graph shows that GDP shocks have a small but increasing positive effect on NMR over time, suggesting minor feedback from economic growth to migration.
- NMR to NMR: The middle graph shows that NMR responds strongly to its own shocks in the first period, then stabilizes near zero, indicating self-correction.
- NMR to UR: The right-middle graph shows that unemployment shocks slightly reduce migration initially, followed by small oscillations around zero, indicating weak responsiveness of migration to unemployment shocks.

Response of UR (Unemployment Rate):

- UR to GDPC: The bottom-left graph shows that GDP shocks lead to a gradual increase in unemployment over time, reflecting potential lagged labor market adjustments.
- UR to NMR: The middle-bottom graph shows that migration shocks initially reduce unemployment, then the effect stabilizes near zero, suggesting limited influence of migration on short-term unemployment.
- UR to UR: The bottom-right graph shows unemployment responds positively to its own shocks and remains relatively persistent across the 10 periods, reflecting inertia in labor market dynamics.

Overall, GDP reacts positively to migration shocks and negatively to unemployment shocks. Migration is mostly self-correcting and weakly affected by GDP or unemployment. Unemployment is persistent and largely influenced by its own past values, with limited responsiveness to GDP or migration shocks. These dynamics confirm that migration contributes positively to growth, while unemployment dampens GDP, consistent with your VECM and IRF table results.

e. Variance Decomposition

The Variance Decomposition is a statistical tool that is used in a Vector Autoregression (VAR) model to quantify how much a shock in one variable contributes to the forecast error variance of other variables. Put simply, the percentage of future fluctuations in a variable that can be explained by shocks to each variable in the system is shown. It is used to provide a quantitative measure of the relative importance of each variable's shocks, complementing impulse response functions.

The results are given in table 6 and are also presented in figure 3 as stacked bar charts to visually represent the percentages. In these charts, the forecast error variance of one variable is shown to be broken down and explained by shocks to each of the variables in the model over time.

Table 6: Variance decomposition

Variance Decomposition of GDPC:

Period	S.E.	GDPC	NMR	UR
1	166.0332	100.0000	0.000000	0.000000
2	207.6071	97.37633	2.606336	0.017333
3	265.2957	78.19901	2.959249	18.84174
4	290.9330	75.89966	4.986011	19.11433
5	323.7612	69.57755	11.85640	18.56605
6	344.4524	66.99855	13.47186	19.52959
7	360.9274	66.21099	14.27033	19.51868
8	380.9945	64.08514	16.68707	19.22779
9	399.4964	62.05929	18.35408	19.58663
10	414.6796	61.01357	19.30604	19.68039

Variance Decomposition of NMR:

Period	S.E.	GDPC	NMR	UR
1	0.393659	3.908265	96.09174	0.000000
2	0.436100	4.859453	94.92777	0.212775
3	0.468785	4.210959	82.82236	12.96668
4	0.491560	5.660495	77.26320	17.07631
5	0.500100	7.258579	75.96936	16.77206
6	0.508420	9.327964	73.50384	17.16819
7	0.522770	12.13495	69.91384	17.95121
8	0.534479	14.92619	67.28229	17.79152
9	0.545513	17.64430	64.58922	17.76647
10	0.558596	20.47853	61.65821	17.86326

Variance Decomposition of UR:

Period	S.E.	GDPC	NMR	UR

1	0.634783	4.005310	0.458852	95.53584
2	0.812019	2.474636	5.348207	92.17716
3	1.040281	1.523351	16.04641	82.43024
4	1.178667	1.588856	17.23893	81.17222
5	1.280023	1.658743	17.95921	80.38204
6	1.392763	1.707612	20.06288	78.22951
7	1.504003	1.861399	21.12026	77.01834
8	1.597105	2.044116	21.73937	76.21651
9	1.688007	2.175295	22.68662	75.13808
10	1.777465	2.310178	23.36822	74.32160

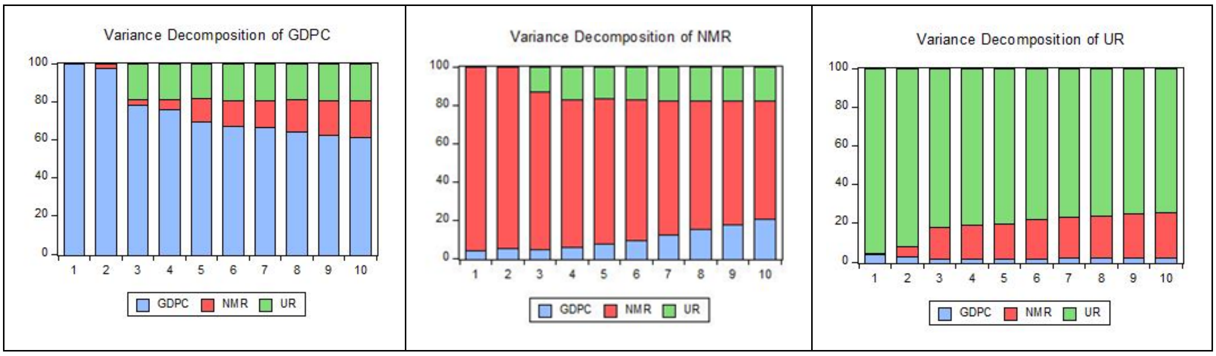

Figure 3; Stacked graphs of variance decomposition

Interpretation

Variance Decomposition of GDPC

The table for GDPC shows the percentage of its forecast error variance that is explained by shocks to GDPC, NMR, and UR over a 10-period horizon.

- Period 1: 100% of the GDPC forecast error is explained by its own shocks. This is expected in the first period, as shocks have not had time to propagate to other variables.
- Period 2: GDPC shocks still dominate, explaining 97.38% of the GDPC variance. However, a small portion is now explained by NMR shocks (2.61%) and UR shocks (0.02%). This indicates the beginning of cross-variable influence.
- Long-Term (Period 10): By the 10th period, the influence of other variables becomes more significant. Shocks to GDPC now explain 61.01% of its own variance, a substantial decrease from the initial 100%. Shocks from NMR have a growing impact, contributing 19.31%, and shocks from UR also have a considerable and stable effect, contributing 19.68%. This suggests that in the long run, GDPC's fluctuations are driven not only by its own dynamics but also by significant influences from the Unemployment Rate and Net Migration Rate.

Variance Decomposition of NMR

This table shows the sources of forecast error variance for the Net Migration Rate (NMR).

- Period 1: 96.09% of the NMR forecast error is explained by its own shocks. A minor portion (3.91%) is explained by GDPC shocks, likely due to the Cholesky ordering where GDPC is ordered first, implying it has an immediate impact on NMR.
- Long-Term (Period 10): The influence of its own shocks diminishes to 61.66%. The contribution from GDPC shocks grows substantially over time, reaching 20.48% by period 10. Shocks from UR also become a significant factor, explaining 17.86% of the NMR's variance. This indicates that NMR is sensitive to changes in both economic conditions (GDPC) and the labor market (UR) in the long run.

Variance Decomposition of UR

This table breaks down the forecast error variance for the Unemployment Rate (UR).

- Period 1: The UR's own shocks are the primary driver, accounting for 95.54% of its variance. Shocks from GDPC (4.01%) and NMR (0.46%) have a smaller, but non-zero, immediate effect.
- Long-Term (Period 10): The contribution of the UR's own shocks falls to 74.32%. This is a less dramatic decrease than seen in the other variables, suggesting that the Unemployment Rate is relatively more driven by its own internal dynamics. However, shocks from NMR become a very important external factor, contributing 23.37% to UR's variance. GDPC shocks remain a minor contributor, explaining only 2.31% of the variance by the 10th period.

Overall, the variance decomposition table reveal the dynamic causal relationships among the variables. The results suggest a complex interplay where all three variables are influenced by shocks from the others, particularly in the long run.

Economic and theoretical Interpretation

The results of the impulse response functions (IRFs) and variance decomposition align with established macroeconomic theory regarding the relationship between migration, unemployment, and economic growth.

- GDP reacts positively to migration shocks and negatively to unemployment shocks.
  - ✓ Migration and GDP: The positive response of GDP per capita (GDPC) to a net migration rate (NMR) shock is consistent with a key theoretical argument in migration economics: immigration as a growth factor. Immigrants can increase GDP per capita by expanding the labor supply, bringing new skills and innovation, and boosting aggregate demand. This aligns with modern growth theory models that incorporate labor force growth and human capital accumulation as drivers of economic output.
  - ✓ Unemployment and GDP: The negative response of GDPC to an unemployment rate (UR) shock is a clear illustration of Okun's Law, which postulates a negative relationship between unemployment and economic output. When the unemployment rate rises, it signifies an underutilization of labor resources, leading to a reduction in the country's overall economic production.
- Migration is mostly self-correcting and weakly affected by GDP or unemployment.
  - ✓ This finding suggests that NMR is largely driven by its own momentum and by factors not included in the model, such as migration policies, social networks, and push factors in a migrant's home country. This is a common theoretical finding, as migration decisions are often complex and not solely determined by the immediate economic conditions of the destination country. The weak response of NMR to GDPC and UR shocks indicates that while economic conditions are a "pull factor," their short-term impact on migration flows may be less significant than other non-economic drivers.

- Unemployment is persistent and largely influenced by its own past values, with limited responsiveness to GDP or migration shocks.
  - ✓ Persistence: The high persistence of unemployment shocks confirms the theoretical concept of labor market stickiness or hysteresis. This suggests that unemployment, once established, can be difficult to reduce, as factors like skill depreciation and social barriers can keep individuals from re-entering the workforce even as economic conditions improve.
  - ✓ Migration and Unemployment: The finding that migration has a limited but negative effect on unemployment (as seen in the provided results) challenges the common notion that an influx of migrants necessarily increases competition for jobs and raises the unemployment rate. This could be explained by several economic theories:
    - a) Labor Market Complementarity: Immigrants often fill jobs that native-born workers are unwilling or unable to do, complementing the existing workforce rather than competing with it.
    - b) Increased Demand: Immigrants are also consumers, and their spending can create new jobs, thus offsetting any potential negative effects on unemployment.
    - c) Entrepreneurship: A higher propensity for entrepreneurship among migrants can also lead to job creation.

Overall, the economic and theoretical interpretations of these results confirm that migration has a supportive role in economic growth and labor market dynamics. The model's findings are consistent with established economic theories on the relationship between macroeconomic variables, highlighting the importance of considering these complex interactions when analyzing the impacts of migration.

f. Comparison with previous studies

The findings of this study on the dynamic interactions among net migration, unemployment, and GDP per capita in Morocco align with and contribute to the existing body of economic literature on migration.

Our results, particularly the positive long-run relationship between net migration and GDP per capita, are consistent with the general consensus found in studies on developed economies. Research by Jaumotte et al (2016), Boubtane et al (2016), and Dritsaki and Dritsaki (2021) all support the view that immigration boosts economic output by enhancing labor productivity and human capital. This paper extends this finding to an emerging economy like Morocco, confirming that a well-managed migration flow can be a positive force for growth in a developing-country context as well.

Furthermore, our finding of a negative relationship between unemployment and GDP per capita is a direct empirical validation of Okun's Law in the Moroccan context. This underscores the universal principle that labor market underutilization acts as a significant drag on economic output, a point that is implicitly supported across the broader literature.

A key contribution of this study is its point of divergence from some country-specific research. The findings of this paper contrast with those of Touhami and Kharkhach (2019), who found a negative impact of Sub-Saharan immigration on Morocco's GDP per capita. Our analysis, which considers the total net migration rate over a longer time horizon, suggests a different conclusion: that the overall effect of net migration on the economy is positive and long-lasting. This highlights the importance of analyzing aggregate migration flows and long-run dynamics, rather than focusing solely on specific migration types or shorter time frames.

Finally, the VECM results that show the minimal short-run responsiveness of both net migration and unemployment to economic disequilibrium are noteworthy. This supports the notion of labor market stickiness and suggests that migration flows are largely driven by exogenous factors not fully captured in our model, reinforcing the observations of Seyhan and Seyhan (2024) that the relationship between economic variables and migration is often complex and not strictly one-way.

5. Conclusion

This study successfully investigated the dynamic relationships between net migration (NMR), the unemployment rate (UR), and GDP per capita (GDPC) in Morocco, addressing a notable gap in the existing literature. The application of a Vector Error Correction Model (VECM) for the period 1991–2024 provides crucial insights into both the short- and long-run interactions of these key macroeconomic variables.

The preliminary analysis using the Augmented Dickey-Fuller (ADF) test confirmed that all three variables were non-stationary at their levels but became stationary after first differencing. This finding, that all series are integrated of order one, I(1), provided the necessary foundation for a cointegration analysis.

The Johansen cointegration test, specifically the more robust Trace statistic, revealed the existence of a single, stable long-run equilibrium relationship among GDPC, NMR, and UR. This is a critical finding, as it indicates that despite short-term fluctuations, these variables are fundamentally linked in Morocco's economic system.

The normalized cointegrating vector further illuminated this relationship:

- A positive long-run effect of net migration on GDP per capita was identified. This result aligns with modern economic theory, which posits that migration can stimulate economic growth by expanding the labor force, increasing human capital, and boosting domestic demand. For Morocco, a country with a significant diaspora, this finding is particularly important, as it confirms that net migration inflows—whether from returning nationals or new immigrants—contribute positively to the nation's economic well-being.
- The unemployment rate was found to have a negative effect on GDP per capita, a result that is consistent with Okun's Law. This finding underscores the economic inefficiency caused by an underutilized labor force, confirming that high unemployment acts as a drag on per-capita output in Morocco.

The short-run dynamics captured by the VECM's error-correction coefficients offer further insights. The significant and negative coefficient for GDPC indicates that GDP per capita actively and rapidly adjusts to correct for any deviations from the long-run equilibrium. In contrast, the negligible adjustment coefficients for NMR and UR suggest that migration flows and unemployment are largely exogenous, meaning they do not respond to bring the system back to equilibrium in the short run. This highlights the self-perpetuating or "sticky" nature of migration and unemployment in Morocco, influenced by factors outside the immediate economic model, such as migration policies, social networks, or structural labor market rigidities.

The findings of this study have important implications for policymakers in Morocco.

1) The positive long-run impact of net migration on GDPC suggests that well-managed immigration policies can be a powerful tool for fostering sustainable economic growth. Policies that attract and retain skilled labor and facilitate the integration of migrants could yield significant economic dividends.
2) The negative effect of unemployment on GDPC reinforces the urgent need to address Morocco's persistent structural labor market challenges. Policymakers should focus on implementing targeted employment policies aimed at reducing underutilization of labor and boosting productivity.

In conclusion, this paper provides robust empirical evidence that net migration and unemployment are not isolated phenomena but are dynamically and causally linked to Morocco's economic performance. The results underscore the critical and positive role of migration as a driver of long-term economic growth while highlighting the persistent challenge posed by unemployment. This research contributes to a more comprehensive understanding of the complex interplay between labor mobility and economic development, offering a data-driven basis for future policy decisions in Morocco.

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