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OPEN ACCESS ARTICLE

THE IMPACT OF REMITTANCES ON EXCHANGE RATES IN WEST AFRICAN MONETARY ZONE (WAMZ)

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Abstract

The study investigates the impact of remittances on the real exchange rate of West African Monetary Zone (WAMZ) member countries by using annual data from six countries from 1960 to 2022. The WAMZ member countries are Ghana, The Gambia, Nigeria, Guinea, Liberia and Sierra Leone. Remittances are important sources of foreign capital for developing countries including WAMZ. The study is unique because it examines three periods namely: Pre-WAMZ (1960-2000), During WAMZ (2001-2022) and the entire period (1960-2022); captures and compares how the increase in receipt of migrant remittances have affected the real exchange rate for the different periods given the huge increase in remittances in the last two decades; use updated data for longer period; shows how the different explanatory variables changes in the three periods examined. Multicollinearity tests, results reveal no multicollinearity among the variables.

Keywords: *Remittance; Real exchange rate; Panel data; West African Monetary Zone.*

INTRODUCTION

Remittances from migrants pose an important source of income for households in many developing countries. The value is rising and its role in promoting better living conditions and economic performance are very important and visible. Acosta et al., (2006) posit that migrant remittances are driven by increased international migration, technological advancement and financial competitiveness and these result in the fall in the cost of transmitting funds from one part of the world to another part. Migrant remittance is ranked second most important source of external funding for developing countries after foreign direct investment (Mallick & Mahallick, 2005; World Bank, 2014; Zouhaier, 2019).

Capital inflows have shown to be very important in the economies of developing countries, especially in the form of private capital inflow which is composed of foreign

direct investment, employee remittance, and portfolio investment. The countries have witnessed a massive rise in these flows in the recent decades and the composition and magnitude have witnessed a significant change. Remittances remain one of the major components of capital flows. The continents of North Africa, South Asia and Middle East have witnessed a constant increase in the level of remittances in recent years. According to the World Bank, Nigeria accounted for the highest remittances flow into Sub-Saharan Africa in 2022. Remittance flow into the Sub-Saharan Africa was $ 53 billion, with Nigeria having 38% ($ 20.1 billion), next is Ghana and Kenya with $ 4.7 and $ 4.1 billion respectively (World Bank, 2023). Growth in remittances to Middle East and North Africa declined by 3.8% to $ 64 billion in 2022 despite strong growth of 12.2% in 2021. The World Bank report asserts that the overall rise in remittances to the Sub-Saharan African region have helped several struggling African countries that are grappling with drought, flood, and debt servicing issues.

Further, governments of many developing countries including WAMZ have since realized the important role that migrant remittance plays as a source of external finance. Remittances emanate from migrants when they send money back home to their families; this serves as an important lifeline for the countries and comprise a share of the gross domestic product (GDP) for the recipient developing countries.

Research problem

In recent decades, developing countries have received a lot of cross-border remittance flows. The WAMZ member countries have benefitted from remittances inflow in the form of transfers to embassies, churches, non-governmental organization which have received billions of dollars. Although remittances have contributed to the WAMZ member countries' economies, these suppositions have not been backed by funding from any rigorous macro-econometric study (Adenutsi & Ahortor, 2008). The Central banks have not shown leadership by providing adequate monetary policy formulation to attract maximum remittances to these countries.

Further, remittances appear to be a challenge in the understanding of the influence of global finance on national policy choices in the developing countries. Remittance is a form of capital inflow and has some unusual characteristics such as they are 'unrequited' and hence do not result in claims on assets, debt services obligation or contractual obligations (Brown, 2006; Kapur, 2005).

On the other hand, since purchases of financial or productive assets can be liquidated, remittances cannot be withdrawn from a country expose and not lumped together with other capital flows that cause household insecurity or income volatility e.g FDI and portfolio flows (Ahlquist, 2006; Garrett, 1998; Scheve & Slaughter, 2004). Migrants tend to increase remittances they send to their countries when their home countries experience

wars, famine or any economic difficulties as these remittances help smooth the income of families and protect them from the uncertainty and inconsistencies of the global economy. Financial transfers and inflows from migrants can serve as a form of insurance for developing countries against exogeneous shocks (Kapur, 2005; Lopez-Cordova & Olmedo, 2006; Lucas & Stark, 1985).

Motivation of study

The main Objective of this study is to determine the impact of Remittances on the exchange rates of WAMZ member countries. There is widespread general belief that remittances have contributed to the economy of WAMZ member countries, but this assertion has not been backed by many macro-econometric studies. The role played by the Central bank in monetary policy formulation to attract maximum cross-border remittances to member countries still lacks some perspectives. Remittances have assisted receiving countries in poverty and inequality reduction, enhancement of human capital and financial development, reduction of labor supply, appreciation of real exchange rate and weaken the tradeable sector of receiving countries.

The research question of this study is to assess the impact of remittances on the currencies and exchange rate of the WAMZ countries. Remittances flows are largely influenced by migrants who depart their home countries and community in search of greener pastures in advanced countries. The continuous increase in migrants to advanced regions also comes from WAMZ member countries which have contributed significantly to the upward trend within Sub-Saharan Africa and to continuous increase in remittances inflows to these countries.

WAMZ is a monetary union. The presence of WAMZ has influenced the flow of remittances has on the exchange rate. The pre WAMZ period (1960-2000), the during the WAMZ period (2000-2022) and the entire period (1960-2022) shows how WAMZ has exhibited different effects of remittances on the exchange rate. Theories such as altruism, self-interest portfolio management e.t.c have motivated remittances flow and driven by need to cater for the welfare of relatives back in their home countries and communities.

Contributions of the study

The formation of WAMZ in 2000 has shown some significant effects in the exchange rate policies of member countries of the WAMZ. Studies reveal that prior to WAMZ formation, member countries had divergent real exchange rates. After WAMZ formation, a growing convergence in real exchange rate was observed among four countries namely:

Nigeria, Sierra Leone, the Gambia, and Liberia (Nketiah et al., 2019). The WAMZ member countries have three exchange rate policy regimes namely fixed exchange rate regime; the intermediate; and the flexible or free-floating regime. The appropriate exchange rate regime is a key factor in achieving the proposed single currency (ECO). Given that WAMZ has the intention of deepening economic integration in the Economic Community of West African States (ECOWAS), the economic cost include the associated nominal exchange rate flexibility which serves as a policy instrument and buffer for adjusting asymmetric shocks.

Exchange rate is considered the most important price in an open economy and arguably the most important macroeconomic policy domain for governments in developing countries (Cooper, 1999). Remittances are important in influencing exchange rate policy making in WAMZ member countries, they also influence political institutions, interest groups and other aspects of the political economy. Remittances alleviate the political costs of lost monetary policy autonomy especially as they react in a countercyclical way to economic downturn and then insulate policy makers from economic uncertainty and volatility.

Remittances contribute in a positive way to the implementation of fixed exchange rates and have the capacity to act as a surrogate for domestic monetary policy autonomy in the WAMZ and other developing countries. Using Robert Mundell's (1961) optimum currency area framework, Singer (2010) posits that migrant remittances have a similar function as cross-border government transfers in the way they allow domestic economy to adjust to fixed exchange rate.

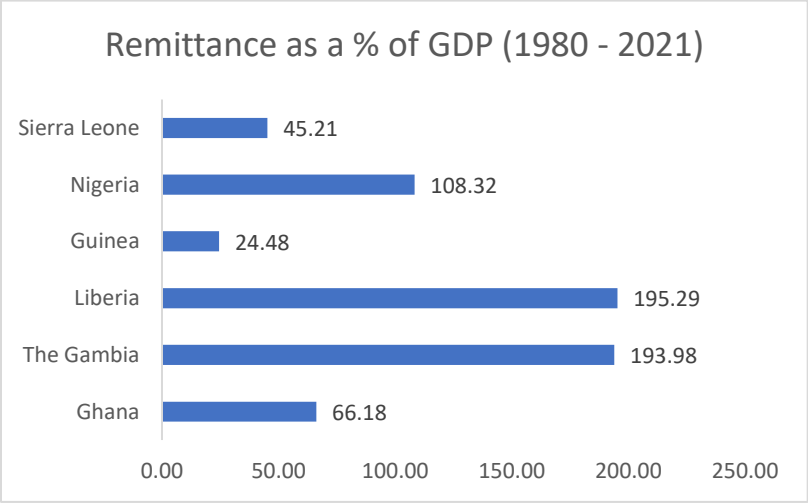

FIG. 1. REMITTANCE AS A % OF GDP (1980-2021)
Source: World Development Indicator

Remittance contributes significantly to the GDP of many WAMZ countries (Fig. 1). Data from World Development Indicator (WDI) show that Liberia received remittances and it

contributes the highest to its' GDP compared to other WAMZ member countries. This shows the huge efforts and altruism of their immigrants towards giving back to their families back home and their country. The study contributes to existing literature and knowledge on how remittances inflows can be controlled or promoted because it makes significant contribution to productivity and the economy of WAMZ. Trade is promoted and economic activities are sustained with remittance inflows.

Hypothesis

Null Hypothesis: H_0: Remittances have no significant impact on the Exchange rate in WAMZ.

Alternative Hypothesis: H_A: Remittances have significant impact on the Exchange rate in WAMZ.

LITERATURE REVIEW

Theoretical review

Several studies capture the effect of remittances on the exchange rate. Hassan and Holmes (2013), Lartey et al (2012) and Maklouhf and Mughal (2013) assert that persistent inflows of remittances exercise upward pressure on the long run real exchange rate, which then results in Dutch disease effects related to a decline in the competitiveness of receipts' countries tradeable sectors. Given the interests in Fiscal Policy, Abdih et al (2012a) place emphasis on the impact of remittances on government revenues, then estimate for several recipient countries, the fiscal implications of the cut back in worldwide remittances in 2009 emanating from the global financial crisis. Abdih et al (2012b) investigate the adverse impact that remittances have on the quality of institutions through two main channels namely: the expansion in the revenue base distorts government incentive which lowers the cost of appropriating resources for its own purpose; and the supplemental income available to households increases their ability to purchase goods and substitutes for government services.

Furthermore, Amuedo-Dorantes and Pozo (2004) examine the impact of workers' remittances on real exchange rate using a panel of 13 Latin America and Caribbean countries. Using instrumenting for remittances leads to a conclusion that remittances appreciate real exchange rate in remittance-receiving countries. Hence, remittances have the potential to enforce economic costs on the export sector of receiving countries by reducing their ability to compete internationally. They utilize a set of variables that are related to remittance -receiving countries as instruments for remittances. Ball et al, (2013)

utilize a panel consisting of 21 countries and show theoretically and empirically that remittances appreciate real exchange rate under both flexible exchange rate regime and fixed exchange rate.

Empirical Review

Edwards (1989) attempts to explain exchange rate volatility by using a theoretical model to capture the long run and short run fluctuations that exist in the exchange rate of developing countries. He displayed a dynamic small open economy model to explain the effect of nominal and real variables on the real exchange rate. The theoretical model posited that equilibrium real exchange rate is determined by real variables which can affect the long run equilibrium real exchange rate and the model was tested using 12 developing countries with data from 1962 to 1985. The results reveal that nominal variables affect the real exchange rate only in the short run while in the long run, the real exchange rate is affected by only real variables. Ahmed (2009) affirmed the Dutch disease hypothesis for Pakistan by estimating a linear regression model using variables namely Terms of trade, government spending, degree of openness, workers remittances, Foreign direct Investment (FDI) and real exchange rate.

METHODOLOGY

Theoretical model

Mundell (1963) and Fleming (1962) provide a framework for how macroeconomic policies are conducted in the presence of capital flows. The Mundell-Fleming model is an extension of the IS-LM model in an open economy setting with the hallmark assumption of sticky prices (Mark, 2001). Traditionally, the Mundell – Fleming models generally deal with fiscal and monetary policy effectiveness in the presence of global capital mobility that exist within the regimes of flexible or fixed exchange rate. These models could predict the impact of domestic and external shocks and the co-movement of macroeconomic variables at home and abroad.

The modification and incorporation have produced two types of models namely (Adenutsi & Ahortor, 2008):

1) Deterministic Dynamic Mundell-Fleming models, and
2) Stochastic Dynamic Mundell-Fleming models.

Empirical model

To examine the impact of remittance inflows on exchange rate, a model takes cognizance of various theories and outcome of previous empirical research such as Gapen & Montiel (2008), Quartey (2006), Vargas-Lundius (2004), Rapport & Docquier (2006) were specified. The empirical model takes insights from the theoretical model in the choice of variables

for the model and shows the relevance of the variables in explaining the theoretical framework and relationship. The justification for the variables is backed by economic theory on how the variables individually influence the personal remittances and it expresses the functional relationship between the dependent variable and these independent variables.

In the light of the above and drawing insights from Nketiah et al., (2019), Loto and Alao (2016), and McMahon(1998) models, this model posits that real exchange rate is a function of per capital remittances received, per capita income, trade openness, ratio of government expenditure to GDP and capita flow.

$$ERR = f(PCR, PCI, TOP, GEX, CI)$$

Method of analysis

The nature of the study entails the use of panel data for the period 1960 – 2022. Panel data is apt because it can identify parameters in the occurrence of measurement error and have robustness to omitted variables and the capture the efficiency of parameter estimates. The panel robust least squares (Panel RLS) estimator would be used to estimate the model for impact of remittance on exchange rate in WAMZ. The variables would be tested for unit root and cointegration test would be performed to determine if there is a long-run relationship among variables of the model or not.

The study captures three periods to enable us to explain the effect of WAMZ. The three periods are:

- Pre-WAMZ period (1960-2000)
- During WAMZ period (2000-2022)
- Entire Period (1960-2022).

Data description

The data type is secondary data, and it uses a panel data set for the six countries of WAMZ. The countries comprise Nigeria, the Gambia, Guinea, Sierra Leone, Ghana and Liberia. WAMZ is our focus because it is an important monetary union that is instrumental in the promotion of regional integration and development of sub-Saharan Africa and provides an institutional framework that policy discussion and implementation. The period of study is 1960-2022 based on availability of data.

Research Question

How does remittance impact the exchange rate and currencies of the WAMZ countries?

Remittances can propel the growth of new small-scale businesses and then foster entrepreneurship by relaxing credit constraint for receiving countries. Remittances can mitigate the exchange rate volatility derived from the outflow and export by providing an indirect stabilizing effect of exchange rate volatility in times when other kinds of capital flows experience fluctuations and then offer regular source of foreign currency into the receiving country economy.

Data from six WAMZ countries from 1960 to 2021 would be used to investigate the impact of remittances on real exchange rates and net exports.

Net exports will require the instruments to address endogeneity of worker's remittances and the instrumental variables are: weighted average per capita GNI, unemployment rate and real interest rate of remittance sending countries

Model

We use a panel of 6 countries in WAMZ to analyze how workers' remittances affect real exchange rate and net exports. We estimate the relationship and can be written as:

$$E_{it} = \beta_0 + \beta_1 R_{it} + \beta_2 I_{it} + \beta_3 OP_{it} + \beta_4 X_{it} + \beta_5 CF_{it} + \alpha_i + \delta_t + \varepsilon_t$$

Where:

E_{it} = real exchange rate

R_{it} = per capita remittances received by country I at year t

I_{it} = Per capita income

TOP_{it} = Trade Openness = (import + export/GDP)

X_{it} = ratio of government expenditure to GDP

CF_{it} = Capital flow (FDI + foreign aid)

δ_t= time fixed effect

α_i = country fixed effect

ε_{it} = Error term

ε = Error term

Based on apriori expectations, we expect that:

$$\beta_1 > 0, \beta_2 > 0, \beta_3 > 0, \beta_4 </> 0, \beta_5 > 0$$

The real exchange rate for the country I at time *t* is defined as

$$E_{it} = e_{it} \times P_{us}/P_{it}$$

Where:

e_{it}=nominal exchange rate

P_{it} = price index

P_{us} = US price

Price index can be the GDP deflator or CPI.

Estimation techniques

The OLS regression technique will be used to analyze the data. Stationary tests, heteroskedasticity, Augmented Dickey-Fuller unit root tests will be applied. Additionally, Fixed effect, cointegration and stability tests will be applied. Descriptive statistics and diagnostic testing such as the Multicollinearity and Pearson correlation test will be implemented in this study.

ANALYSIS, INTERPRETATION AND DISCUSSION OF RESULTS

Real exchange rate descriptive statistics

TABLE 1. REAL EXCHANGE RATE DESCRIPTIVE STATISTICS

	Sierra Leone	Nigeria	Liberia	Guinea	Ghana	The Gambia
Mean	169.0279	147.3131	360.3637	265.9615	358.8717	170.8867
Median	142.6261	133.1625	356.9780	268.7895	141.7449	201.2114
Maximum	561.1871	536.9107	414.8943	301.6783	3053.589	269.8880
Minimum	91.35220	49.77631	304.7840	213.8970	68.18191	72.75780
Standard Deviation	92.86049	94.80168	40.06086	33.39289	474.2842	57.61883
Skewness	2.531822	2.327921	0.273207	-0.503789	3.631547	-0.358573
Kurtosis	9.589486	8.644007	1.693035	1.680806	19.26431	1.838800
Jarque-Bera	181.2873	140.5206	5.267653	7.233154	832.8608	4.889546
Probability	0.000000	0.000000	0.071803	0.026875	0.000000	0.086746
Sum	10648.76	9280.723	22702.91	16755.58	22608.92	10765.86
Sum Sq Dev	534630.4	557216.3	99502.11	69135.29	13946619	205835.6
Observations	63	63	63	63	63	63

Source: Researcher's computation from WDI data

The average real exchange rate of Liberia is the highest among the six countries of WAMZ for the 63-year period while Nigeria recorded the lowest average real exchange rate among the WAMZ countries for the same period (Table 1). Ghana recorded the highest maximum value for the real exchange rate while Nigeria recorded the least minimum value for the real exchange rate. The kurtosis and skewness statistics measure the departure from symmetry and peaked ness of the distribution respectively. The data collected show that the positive skewness is quantitatively high, and this justifies the high

level of the peak value. Additionally, the high real exchange rate for Liberia implies that Liberia is losing its competitive edge more and the exports are more expensive while the imports are less expensive. The increase in productivity tend to lead to lower production costs and lead to a rise in the real exchange rate. On the other hand, Nigeria with the lowest real exchange rate implies that it gains some competitive edge, the exports are cheaper while the imports are more expensive. Nketiah et al (2019) posit that increase in capital flows is a function of stock of assets and liabilities in the economy and increase in net foreign assets leads to changes in the real equilibrium exchange rate. Remittance affects the real exchange rate through their impact on growth. Even though the impact on growth is uncertain from our results, Lopez et al., (2007) assert that remittances lead to a significant appreciation in real exchange rate.

Panel data regression

The panel data regression involves five explanatory variables and the dependent variable of real exchange rate. Regression was done for three periods to enable us to compare the impact on the variable during the various changing times. The first period is the pre-WAMZ period (1960-2000), the second period is during the WAMZ (2001-2022) and the third period is the entire period of study (1960-2022).

$$RER_{it} = \alpha + \beta_1 PCI_{it} + \beta_2 PCR_{it} + \beta_3 GFCE_{it} + \beta_4 CF_{it} + \beta_5 TOP_{it} + \delta_t + \alpha_i + \mu_t$$

Pre-WAMZ period

TABLE 2. PRE-WAMZ PERIOD

Variable	Coefficient (Standard Error)	P-value
Dependent Variable: Real Exchange rate		
Per capita Income	0.070543 (0.077099)	0.3611
Per capita Remittance received	9.659054 (3.644316)	0.0086
Government Consumption Expenditure	-0.823915 (2.516104)	0.7436
Capital Inflow	-2.25E-07 (6.80E-08)	0.0011
Trade Openness	-0.466055 (0.292587)	0.1125
Constant	302.1122	
R-squared	0.064075	
Adjusted R-squared	0.044577	

$$RER_{it} = 302.1122 + \beta_1 0.070543 + \beta_2 9.659054 + \beta_3 -0.823915 + \beta_4 -2.25E-07 + \beta_5 -0.466055 + \delta_t + \alpha_i + \mu_t$$

In the pre-WAMZ era, the variables per capita remittance and capital inflow were statistically significant while the variables per capita income, Gross final consumption expenditure and trade openness were not significant (Table 2). This implies that we reject the null hypothesis and conclude that Remittances have significant impact on real exchange rate for the variables per capita remittance and capital flow while we fail to reject the null hypothesis and conclude that remittances have no effect on exchange rate for the variables Per capita income, Gross final consumption expenditure and Trade. Also, for per capita remittance, one unit increase will result in an increase in the real exchange rate by 9.65905 while holding other variables constant. From the result, the positive relationship between per capita remittance and real exchange rate is in consonance with Economic theory. An increase in remittance causes an appreciation of the exchange rate, increase in the capital account and external imbalance. Giving the increasing population to explain the per capita remittance, the remittances received will lead to appreciation of the real exchange rate. For the capital inflow, the negative relationship in the result is not in consonance with economic theory. This means that if the capital inflow increases by one unit, then the real exchange rate decreases by 2.25E -07 while holding other variables constant. An increase in capital inflow leads to currency appreciation, but a decrease in net exports and aggregate demand. Capital inflow produces high demand for both tradeable and non-tradeable goods which leads to higher relative prices of non- tradeable goods and appreciation of the real exchange rate.

During WAMZ

TABLE 3. DURING WAMZ

Variables	Coefficient (Standard Error)	P-value
Dependent Variable: Real Exchange rate		
Per capita Income	-0.017728 (0.016211)	0.2762
Per capita remittances received	0.035792 (0.167035)	0.8307
Government Consumption Expenditure	13.00792 (1.696217)	0.0000
Capital Inflow	-2.35E-09 (5.27E -09)	0.6563
Trade Openness	0.010748 (0.107344)	0.9204
Constant	43.94366	
R-squared	0.421618	
Adjusted R-squared	0.398666	

$$RER_{it} = 43.94366 + \beta_1 -0.017728 + \beta_2 0.035792 + \beta_3 13.00792 + \beta_4 -2.35E-09 + \beta_5 0.010748 + \delta_t + \alpha_i + \mu_t$$

The five explanatory variables are per capita income, per capita remittance, Government final consumption expenditure, capital inflow and trade openness (Table 3). Among these, only the Government final consumption expenditure is statistically significant while the remaining four variables are not significant. The Government final consumption expenditure is highly statistically significant; hence we reject the null hypothesis and conclude that the variable has a significant impact on the real exchange rate. Since the variables per capita income, per capita remittance, capital inflow and trade openness are not significant, we conclude that they do not have impact on the real exchange rate during WAMZ. If the Government consumption expenditure increases by one unit, we expect the real exchange rate to increase by 13.00792 while holding other variables constant. While Government purchases and expenditure causes the real exchange rate to appreciate, increase in consumption in developing countries especially WAMZ leads to depreciation of the real exchange rate.

Entire period

TABLE 4. ENTIRE PERIOD

Variable	Coefficient (Standard Error)	P-value
Dependent variable: Real Exchange rate		
Per Capita Income	-0.025783 (0.037833)	0.4960
Per capita remittance received	-0.454901 (0.434583)	0.2959
Government consumption Expenditure	1.476916 (1.866428)	0.4293
Capital Flow	-1.71E -08 (1.42E-08)	0.2285
Trade Openness	0.143473 (0.150347)	0.3406
Constant	248.7431	
R-Squared	0.057581	
Adjusted R-squared	0.044914	

$$RER_{it} = 43.94366 + \beta_1 -0.036001 + \beta_2 -0.621258 + \beta_3 0.372466 + \beta_4 -1.46E-08 + \beta_5 -0.131158 + \delta_t + \alpha_i + \mu_t$$

The five independent variables witnessed changes in the three periods of study (Table 4). For the per capita income, the coefficient was negative in the entire period, positive in the

pre-WAMZ period and negative in the during the WAMZ period. For the per capita remittance, the coefficient was negative for the entire period, positive for the pre-WAMZ period and positive for the during the WAMZ period. For the Government consumption expenditure, the coefficient is positive during the entire period, negative during the pre-WAMZ period and positive during the WAMZ period. For the Capital flow, the coefficient was negative for the entire period, pre-WAMZ and during WAMZ period, but statistically significant for only the pre-WAMZ period. For the Trade openness, the coefficient was positive in the entire period, negative in the pre-WAMZ period and positive in the during the WAMZ period.

Further, from the regression result for the entire period, none of the five explanatory variables were statistically significant, hence we fail to reject the null hypothesis and conclude that all of them do not have significant impact on the real exchange rate. For the per capita income, if it increases by one unit of the dollar, this leads to a decrease in the real exchange rate by 0.0225783 while holding other variables constant. Per capita income is a measure of economic growth, and a high real exchange rate stimulates economic growth. For the per capita remittance, a one unit increase in the per capita remittance received leads to a decrease in the real exchange rate by 0.454901 while holding other variables constant. Economic theory posits that an increase in per capita remittances lead appreciation of the real exchange rate, increase in capital account and external imbalance. For the Gross final consumption expenditure, an increase of one unit is expected to increase the real exchange rate by 1.476916 while holding other variables constant. Increase in government spending stimulates the aggregate demand and causes some real GDP growth and real exchange rate appreciation. The Government expenditure can influence the real exchange rate potentially through the resource withdrawal channel and the consumption tilting channel.

The capital flow has a negative relationship with the real exchange rate for the entire period. If the capital inflow increases by one unit, then the real exchange rate decreases by 1.71E-08 while holding other variables constant. An increase in capital inflow leads to real exchange rate appreciation and a reduction in net exports and aggregate demand. Capital inflow produces a higher demand for both tradeable and non-tradeable goods and then higher relative price for non-tradeable goods. Capital inflow increases the domestic resources needed to produce non-tradeable goods needed to meet the increase in demand. Also, the trade openness has a positive relationship with the real exchange rate and a one unit increase in the trade openness is expected to increase the real exchange rate by 0.143473 while holding other variables constant. An increase in the trade openness

leads to absorption of more real shocks by the currency market which affects nominal shocks. In an open economy, fluctuations in the exchange rate leads to expectations of a depreciation on the national currency.

Correlations

The Pearson correlation test is important because it measures the strength and direction of linear relationship between two variables. It is used to evaluate the strength of association between data and variables. The variables have positive and negative association present among the six variables including real exchange rate.

TABLE 5. CORRELATIONS

		Real Exchange rate	Per capita remittance	Per capita Income	Trade Openness	Government final consumption expenditure	Capital Inflow
Real Exchange rate	Pearson Correlation	1	-.183	-.215	.081	.104*	-.210**
	Sig (2-tailed)		<.001	<.001	.115	.044	<.001
Per capita remittance	Pearson Correlation	-.183**	1	.707*	.108*	-.090	.621**
	Sig (2 - tailed)	<.001		<.001	.036	.082	<.001
Per capita Income	Pearson Correlation	-.215**	.707**	1	-.158**	-.252**	.775*
	Sig (2-tailed)	<.001	<.001		.002	<.001	<.001
Trade Openness	Pearson Correlation	.081	.108*	-.158*	1	.345**	-.114*
	Sig (2-tailed)	.115	.036	.002		<.001	.026
Government final consumption expenditure	Pearson Correlation	.104*	-.090	-.252**	.345**	1	-.189**
	Sig (2-tailed)	.044	.082	<.001	<.001		<.001
Capital Inflow	Pearson Correlation	-.210**	.621**	.775**	-.114*	-.189**	1
	Sig (2-tailed)	<.001	<.001	<.001	.026	<.001	
	N	378	378	378	378	378	378

Real exchange rate has relationship with all the variables (Table 5). Real exchange rate has perfect positive relationship with itself, the relationship with per capita remittance is considered as negligible correlation, negative and there is insufficient statistical evidence that the correlation between two variables is significant. Given that there exists a negative correlation between real exchange rate and per capita remittance, it implies that both variables move in opposite direction and do not move in tandem. When the real exchange rate increases, the per capita remittances decreases and vice versa. Similarly, the real exchange rate has a negative relationship with the per capita income, shows negligible

correlation and there is insufficient statistical evidence that the correlation between two variables is significant. The negative relationship implies that when the real exchange rate increases, then the per capita income decreases and vice versa.

Additionally, the trade openness has a positive relationship with the real exchange rate. It has negligible correlation and there is insufficient statistical evidence that correlation between two variables is significant. The positive relationship implies that the real exchange rate and trade openness move in tandem; if the real exchange rate increases, then the trade openness also increases and if it decreases, the trade openness also decreases. The real exchange rate has a positive relationship with the Government final consumption expenditure. The correlation is negligible and there is insufficient statistical evidence that the correlation between the two variables is significant. The positive relationship between the real exchange rate and Government final consumption expenditure implies that both variables move in tandem with each other and as one variable decreases, the other variable also decreases.

For the capital flow, it has a negative correlation with the real exchange rate. The correlation is negligible and there is insufficient statistical evidence that the correlation between the two variables is significant. The negative correlation implies a negative relation between the capital flow and the real exchange rate, and they do not move in tandem. If the capital flow increases, then the real exchange rate decreases and if the real exchange rate increases, then the capital flow decreases.

Overall, the variables have 36 points of correlation with one another, and the correlations are either positive or negative. Apart from the perfect correlations present, the highest is the correlation between capital inflow and per capita income. The correlation coefficient is 0.775 and it suggests that there is a high positive correlation between the capital inflow and per capital income for the 63-year period in WAMZ. Both variables move in tandem and have a high positive association. In the entire correlation result, there is no multicollinearity. This is because the correlation coefficients are less than 0.8.

Model summary

TABLE 6. MODEL SUMMARY

Model	R	R Square	Adjusted R Square	Std Error of the Estimate
1	.240	.058	.045	215.94319096

From the model (Table 6), it shows that the model does not have good fitness for the entire period. The low R square of 0.058 means that only 5.8% of the variations in the real

exchange rate is explained by per capita income, per capita remittance, Government final consumption expenditure, capital inflow and trade openness while the remaining 94.2% of the variation is unaccounted for. The standard error of 215.943 is high. The standard error is intuitively the standard deviation of a sampling distribution, and it depicts how much disparity there is likely to be between the point of estimates obtained from a sample relative to the true population of the mean. From the high value, it is obvious that that the disparity is quite large.

ANOVA

TABLE 7. ANOVA

Model		Sum Squares	df	Mean Square	F	Sig
1	Regression	1059873.262	5	211974.652	4.546	<.001
	Residual	17346903.760	372	46631.462		
	Total	18406777.022	377			

Note:

1. Dependent Variable: Real Exchange rate
2. Predictors: (Constant), Trade openness, per capita remittance, Government final consumption expenditure, capital inflow, Per capita income

The regression shows that there exists a relationship between real exchange rate and per capital remittance, real exchange rate and per capita income, real exchange rate and Government final consumption expenditure, real exchange rate and capital inflow, and real exchange rate and trade openness. The ANOVA result (Table 7) is important because it informs us that there are significant differences between the means of three or more groups. Also, the test result is statistically significant, and it implies that at least one group's mean differs from others. The 'between' variance is much larger than the 'within' variance and the factor level impacts the mean of the distribution of the variables. The test shows that F-test and adjusted R-squared in the model specification provided evidence that the explanatory variables are jointly not equal to zero, but not a good fit of the model.

Coefficients

The coefficients and their values tell us the relationship each value has with the dependent variable, the real exchange rate (Table 8). There is a negative relationship between the real exchange rate and per capita remittance, capital inflow and per capita income. There is a positive relationship between real exchange rate and the Government final consumption expenditure and trade openness. From the result, none of the variables is statistically significant. This means that none of the variables is a useful predictor of the real exchange rate. Also, the VIF statistics is an indicator to inform us of the presence of multicollinearity or not. Since (Variance Inflation Factor) VIF of 5-10 signifies

multicollinearity, there is NO multicollinearity in the results. This is because all the VIF statistics are less than 5.

TABLE 8. COEFFICIENTS

Model	Unstandardized B	Coefficients Std Error	Standardized Coefficient Beta	t	Sig	Statistics VIF
Constant	248.743	29.980		8.297	<.001	
Per capita remittance	-.455	.435	-.080	-1.047	.296	2.286
Government consumption expenditure	1.477	1.866	.043	.791	.429	1.190
Capital Inflow	-1.714E-8	.000	-.097	-1.206	.229	2.573
Per capita Income	-.026	.038	-.064	-.681	.496	3.431
Trade Openness	.143	.150	.054	.954	.341	1.250

Note: Dependent Variable: Real Exchange rate

The no multicollinearity in the results means that the independent variables are not highly correlated with each other. This means that each predictor makes some important contributions in explaining the outcome. A significant amount of information present in one predictor is not contained in other predictors. The statistical significance of independent variables is NOT undermined.

How has the remittances impacted the exchange rate and economy of WAMZ?

From the results, the correlation coefficient between the predictors and the Variance Inflation Factor (VIF) is considered the most used method by statisticians to test multicollinearity. The values range between 1.19 and 3.43 leads to the conclusion where we fail to reject the null hypothesis of no multicollinearity. There is no multicollinearity, hence the statistical inferences are reliable, and the independent variables interact and affect each other. The Pearson correlation test did show that there exist relationships between real exchange rate and all five independent variables chosen in the model. The relationship was either positive or negative. Per capita remittance variable is proxy for the remittance, and it shows a negative relationship with the real exchange rate. There is negligible correlation, and both variables move in opposite direction. An increase in per capita remittance leads to a decrease in the real exchange rate.

Since the creation of WAMZ in 2000, exchange rate stability has been one of the major goals of the monetary union. Many WAMZ and Sub-Saharan African countries have

exchange rate stability as one of their monetary policy objectives. The creation of WAMZ has led to better coordination and more inflow of FDI and remittances from migrants who are citizens but live abroad. The remittances and capital inflow has led to the appreciation of the real exchange rate in the member countries. Hence, there has been a huge increase in remittance to member countries which have served as sources of livelihood for many families and an important component of the GDP of these countries. The increase in remittances has been driven by having many WAMZ citizens abroad, increased interest/request by home governments, altruism from migrants who live and work abroad. The increase in remittance, which is a component of inflows into the economy has increased consumption in the economy, led to the appreciation of the real exchange, increased the domestic economy, but have not achieved exchange rate stability.

CONCLUSION

International migrants are assiduous in their host countries and save a portion of their income in savings which they remit a part of their savings to their families back home for either support or investment. Remittances are expected to help improve the economy of remittance-receiving countries, but it is not always true. Remittances have the potential of appreciating the real exchange rate of the remittance-receiving countries, hence weakening the competitiveness of their economy, and reducing their exports. We discover that for all the WAMZ countries, an average of 10% increase in per capita remittance will lead to 4.54% reduction (appreciation) in the real exchange rate. The total per capita remittance received by WAMZ countries rose from $ 115 million in 1960 to $ 26.5 billion in 2022.

Moreover, the study examined the impact of remittances on the exchange rate of the WAMZ countries. To analyze the impact of remittances, the ordinary least square method was chosen. The study used time series data and panel data regression for the five explanatory variables that influenced the exchange rate over the 63-year period. Correlation, Multicollinearity and ANOVA tests were done, and we found that many of the variables possessed negligible correlation. Among the explanatory variables, some have a positive relationship with the real exchange rate while others have a negative relationship. The correlation result shows that many were negligible correlation except for per capita income/capital flow, per-capita remittance/per capita income which recorded a high positive correlation, and few others have moderate and low correlation. The F test and adjusted R squared in the model specification show evidence that the explanatory variables are jointly not equal to zero and does not have goodness of fit for the entire period.

Further, the study analyzed the impact using three periods namely: Pre-WAMZ era (1960-2000), during WAMZ era (2001-2022) and the entire period (1960-2022). The

regression results of the variables in the three period differ. In the pre-WAMZ period, the per capita remittance and capital inflow had significant impact on the real exchange rate. In the during the WAMZ era, the Government final consumption expenditure was statistically significant and had an impact on the real exchange rate. In the entire period, none of the variables were significant. The analysis shows that a long run relationship (co-integration) exists among the variables in the entire period. The pre-WAMZ period does not show long run relationship while the during the WAMZ period shows long run relationship for some of the variables.

The research further real that in the entire period, the per capita income, per capita remittance, and capital inflow result in the appreciation of the real exchange rate in WAMZ. The negative relationship with the real exchange rate shows that the variables move in the opposite direction with the real exchange rate and such leads to appreciation. In the pre-WAMZ period, the government consumption expenditure and capital inflow are the variables that propelled the real exchange rate appreciation while in the during the WAMZ period, the per capita income and capital inflow caused the appreciation of the real exchange rate. The Granger causality tests, the Vector Autoregressive (VAR) and the Unit root tests reveal that some variables were significant in their impact on the real exchange rate.

RECOMMENDATIONS

The analysis reveal important issues and we recommend the following:

1) Need for more understanding and emphasis on the economic importance of remittances in the WAMZ member countries' economies.
2) Need to study the consequences of remittance on the export sector because of real exchange rate appreciation that emanates from increasing flows of remittances.
3) The increasing level of remittances has attracted a lot of consideration in WAMZ especially in the last two decades, therefore this calls for new opportunities. More opportunities for investment expenditure on capital goods which will boost income, stimulate production, and increase exports.
4) Need for governments of WAMZ member countries to create investment vehicles such as diaspora bond to encourage the citizens of WAMZ member countries who are immigrants working abroad to contribute towards national development.

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OPEN ACCESS ARTICLE

EXPECTATIONS AND DISAPPOINTMENTS OF SMALL AND MEDIUM-SIZED SOLAR PV POWER PLANT PROSUMERS

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Abstract

Many small investors are considering small and medium-sized photovoltaic (PV) plants as a solution for generating additional renewable energy and gaining quick and easy returns on the investment. However, relying solely on commercial data for investing in such PV plants is not advisable, as several factors may later, during the operation phase, negatively surprise those investors. This paper discusses potential obstacles these small investors may face while investing, operating, and selling electricity generated by such PV plants. The study shows the mismatch between expectations and disappointments regarding the outcomes of such PV plants, further reinforced by recent market analyses and studies in the USA and Spain.

Keywords: *Renewable energy sources (RES); Photovoltaics (PV); Prosumers; Economics; Return on investment.*

INTRODUCTION

The reduction of reserves in primary energy sources, especially fossil fuels, which are currently the dominant source for generating energy, has a strong negative impact on the environment and wildlife. This calls for emergency steps towards utilizing other energy sources and a global energy transition. The energy transition refers to a shift in how we obtain and use electricity, replacing fossil fuels with renewable energy sources (RES) such as solar and wind energy, tidal energy, biomass, biogas, and recently, energy derived from hydrogen and fuel cells. This shift provides significant benefits to various participants in the energy cycle, such as production companies increasing their equipment production volume and turnovers, investors improving their investment portfolio and return on investment, and energy consumers obtaining needed energy from technologically advanced, economically affordable, and environmentally friendly sources.

One of the biggest challenges facing the widespread use of RES is their unpredictable

generation patterns, which can lead to issues with market balancing and integration into existing power grids. To address this, smaller RES power plants have been established that can generate electricity for their owners, but also sell excess power to the distribution network. These fresh players in the market are called *"prosumers,"* which is a combination of *"producer"* and *"consumer."*

Small and medium-sized power plants utilizing solar energy can be attractive investments for prosumers. However, several facts and issues can be problematic for any investor or prosumer interested in constructing and utilizing such power plants. Therefore, it is crucial that potential prosumers carefully investigate these potential drawbacks before making a final investment decision (Jahn, 2003; Mertens, 2014).

In this paper, the authors present several lesser-known facts about the energy production of a solar PV power plant (Jahn, 2003). We will demonstrate that the data presented to potential investors/prosumers about business and financial plans are not always precise and reliable for several reasons. Hence, the expected amount of electricity generated and the projected income from the investment should be taken cautiously.

SOLAR PV POWER PLANTS IN BRIEF

Solar photovoltaic (PV) power plants are electric energy (EE) generation facilities based on the photovoltaic effect. The photovoltaic effect does not need any conductor movement, because in this process certain chemical elements called semiconductors are bombarded by solar energy quanta called photons generating at their terminals a potential difference, i.e., an electric voltage. These energy quanta called photons are fast subatomic and energy-rich particles with no mass and no electric charge that originate from inside the Sun. Each photon contains energy inversely proportional to its wavelength – shorter wavelength, larger energy, and vice versa (Mertens, 2014).

Our planet is constantly bombarded with such photon particles whose total energy far exceeds the energy needs of our planet. Unfortunately, we can use only a few percent of that total energy that constantly falls on the Earth's surface. Using this energy, PV cells directly convert photon's energy into EE. It is important to mention that the PV effect could generate only direct currents (DC), thus it is considered only a DC energy source. Consequently, additional power switching equipment, such as DC/AC converters, inverters, or similar are essential for the PV plant to be commercially applicable.

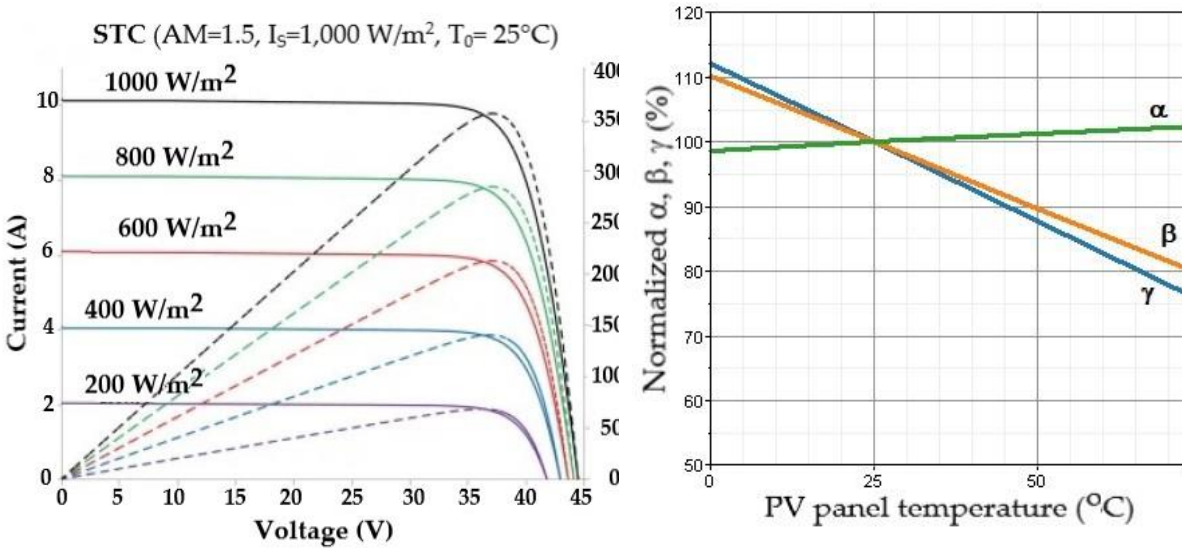
A single solar cell used in PV power generation has low energy density and generates only a small amount of energy, usually just a few watts. This is why they are typically grouped in modules, panels, and arrays, and then combined to form entire PV plants. As a result, PV power plants require large installation areas, ranging from hundreds to thousands of square meters, depending on their size.

MAIN CHARACTERISTICS OF SOLAR PV POWER PLANTS UNDER OPERATION

As a result of the so-called energy transition process, the need for additional EE, and limited so-called *"best-evaluated locations"* with the most favorable PV generation potentials, it is obvious that there is a huge *"hunger"* for easy and quick obtaining favorable locations and licenses for the installation and operation of new PV power plants. At the same time, prosumers who think that they can quickly, easily, and economically achieve production and consumption of EE for their personal needs or gain a quick return on the investment and financial profit by selling part or entire generated EE on the market, appear as the main license applicants. Simply, this *"photovoltaic fever"* included many subjects who do not know enough about the conditions in this extremely unpredictable sector.

One of the most crucial factors in setting up a PV power plant is choosing the right type and producer of PV panels, along with the corresponding DC/AC inverters that can convert the generated DC power into AC power that can be used by most consumers. There are several types of solar panels available in the market, including monocrystal or polycrystal type, monofacial or bifacial, one-piece, or half-cut type panels, agriculture-type panels, etc. Additionally, the same type of PV panel may come with different installed capacities and connections of PV modules within the panel. When selecting PV panels, investors should consider the installation location, their personal preferences, and available investment funds to maximize their benefits (Jahn, 2012). Commercial catalogs or brochures can provide a good starting point for the optimal selection of PV panels for specific locations and purposes. These catalogs typically provide basic information on each type of PV panel, such as maximum power, nominal power, operating voltage, current, and operating temperature. However, it is important to note that most of the data for a particular PV panel presented in these catalogs may never be achieved under real operating conditions.

If you are considering investing in renewable energy, it is essential to keep three crucial factors in mind when it comes to PV power plants. These factors can make or break the success of your investment, so it is vital to take them seriously. With the right considerations and foresight, investing in PV power plants can be a smart and profitable decision (Fthenakis, 2012):



a) *b)*

FIG 1. TYPICAL PV PANEL DATA: a) CATALOG DATA, b) TEMPERATURE COEFFICIENTS

- The maximum power output of a photovoltaic (PV) panel is usually declared under Standard Test Conditions (STC) which include specific internationally standardized operating conditions such as the angle of incidence of the incident sunlight AM, the solar radiation intensity I_S, and the ambient temperature T_0. However, these conditions are rarely, if ever, achieved during the actual operation of a PV power plant (Fthenakis, 2012; Jahn, 2012).

  As a result, the maximum power output declared in catalogs for PV panels can be misleading. For instance, as shown in FIG. 1a, a monocrystalline solar panel with a declared maximum power of 360 W under STC (AM=1.5, I_S=1,000 W/m^2, T_0= 25°C) could generate much less power under real operating conditions. If the solar radiation intensity drops from 1,000 W/m^2 to 600 W/m^2, the maximum output power of the PV cells could drop from the declared 360 W to around 220 W (Fig. 1a). Therefore, it is important to approach the catalog data for the maximum power output of PV panels with caution and more realistic output data reduce it by at least 5-10%.

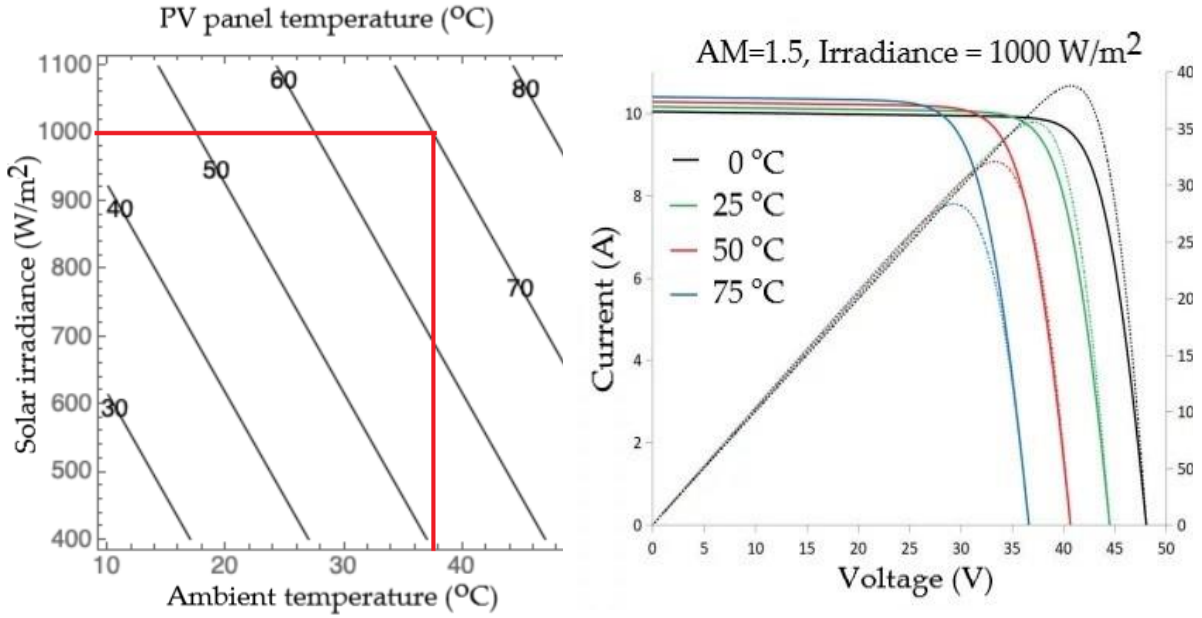
- The amount of electricity generated by solar PV panels is strongly influenced by the ambient temperature (Paudyal, 2021; QPV Research Group, 2019). This is a lesser-known fact, especially for those not experts in PV panel production and usage. PV plant owners may notice reduced production or unexpected results. For instance, they may observe unexpectedly higher energy efficiency (EE) production per hour on a sunny winter day compared to a warm sunny day during the summer months.

  This is because PV panels have three coefficients that strongly affect EE production. These coefficients are the current temperature coefficient α, voltage temperature coefficient β, and power temperature coefficient γ. Their

dependency on the ambient temperature at which the solar panel operates is given in Fig. 1b. The current coefficient α is usually positive but small, resulting in a slight increase in current output. However, the voltage coefficient β is always negative and dominant, decreasing the output voltage of the PV panels. This means that an increase in ambient temperature by 1°C leads to an increase in the output current of the PV panel by the value of the coefficient α but a decrease by the coefficient β, which is almost 10 times larger than α. These two coefficients contribute harmfully to the third one, the power temperature coefficient γ, which is also significantly negative with values of -0.4% to -0.5%. Thus, the output power of the solar panels also decreases by the value of such coefficient γ.

It is unfortunate that the temperature of a PV panel changes rapidly during operation and is highly dependent on the surrounding temperature (QPV Research Group, 2019). FIG 2a provides an estimated correlation between the PV panel temperature, the ambient temperature, and the amount of solar irradiance. For instance, if the solar irradiance is 1,000 W/m^2 and the ambient temperature is 37°C, the estimated PV cell temperature could be as high as 70°C. At this temperature, the PV panel cannot achieve its maximum power production, although the solar irradiation is very high.

Fig. 2b provides a better estimate of the operational characteristics of a single PV panel under different ambient and panel temperatures. If a solar PV panel operates under STC (25°C), the output voltage is 44.5 V, and the maximum power is 360 W. However, if the panel temperature rises to 75°C, then the output voltage drops to 36 V, and the power drops by 22% down to a modest 280 W. The opposite effect is true when the PV panel temperature drops to 0°C. The voltage increases to 48.5 V, and the output power rises by 7% up to 395 W. During summer periods and in locations where PV power plants are installed, the ambient temperature can rise from the nominal 25°C to 40°C, causing the panel temperature to reach 75°C, and the output power of each PV panel decreases by 20%. The opposite is true when the air temperature drops from 25°C to 0°C; the output power increases by 10%. This leads to an apparent energy paradox; PV panels provide hourly more EE during cold but sunny winter days than during hot sunny summer days. However, during the winter period, the daylight is significantly shorter, so there is a lower amount of sunshine, and in general, the daily EE production is lower than the rest of the year. Therefore, it is crucial to provide the best possible cooling conditions for the solar PV panels to reduce their ambient operating temperature.



a) PV panel temperature and solar irradiance influence vs. ambient temperature

b) Output voltage, current, and power vs. solar PV panel temperature

FIG 2. DEPENDENCY OF SOLAR PV PANEL OPERATIONAL CHARACTERISTICS VS. AMBIENT AND PANEL TEMPERATURES

- The third factor that must be considered while preparing a business plan is the reduction in the performance of PV panels over time. This means that with the years of operation, the panels will generate less power from the same amount of sunlight. Various external factors such as weather conditions wear down the panels, reducing their capacity to generate power. Micro cracks that occur in the silicon of the PV panel and the weakening of the electrical connections due to these little fractures result in fewer pathways for the electrons, and therefore less energy reaching the inverter, generating over time less EE power (Svarc, 2023). Moreover, moisture, heat, humidity, ice, and ultraviolet (UV) exposure are the primary factors that cause PV panel degradation, all of which are due to natural causes. The efficiency of a PV panel, which is usually given in the catalog at the time of installation, is between 18% and 24%. However, over the years of operation, its efficiency decreases on average by 0.3% to 1% per year. In other words, the generation of EE under the same operational conditions in 10 or 20 years of operation could be 6% or 20% less than what was expected at the beginning of operation. Table 1 shows the amount of degradation of several LG solar PV panels compared with the other industry average PV panels (Global Solar Report, 2023).

TABLE 1. PERFORMANCE WARRANTY: LG SOLAR PANELS VS. INDUSTRY AVERAGE

Year of operation	LG solar panel type			Industry Average
	NeON R	NeON 2	Mono X Plus	
New	98.0 %	98.0 %	97.5 %	97.0 %
After 1 year	97.7 %	97.6 %	97.1 %	97.4 %
After 10 years	95.0 %	94.7 %	93.5 %	91.0 %
After 25 years	90.8 %	90.0 %	87.9 %	82.6 %

Source: Global Solar Report (2023).

Aside from these three main factors already mentioned that contribute to the decline in the performance of PV panels from their original rating, other factors cannot be avoided over time. These include system or component failures, shading of PV panels, frequent inverter problems, long repair times, bad orientation of PV arrays, and more. Often, the actual amount of energy generated by a PV plant does not align with the expected amount as outlined in the business plan. This discrepancy can cause frustration for investors and make it difficult to achieve the expected investment return rates and payback periods. Therefore, conducting a long-term analysis study is essential for obtaining more accurate predictions and business plans before proceeding with the investments and construction of any new solar PV plant.

COMPARISON BETWEEN EXPECTED AND ACHIEVED ENERGY PRODUCTION

Recently, surveys of the PV markets in the USA have been conducted to gather data on the profitability and realization of expectations from investments. Unfortunately, the results are quite concerning. The US company Raptor Maps regularly releases annual solar reports (Global Solar Report, 2023). In their fifth annual report from 2022, they analyzed existing PV power plants with as much as 24.5 GW of installed capacity and discovered that the loss of electricity relative to the assumed amounts led to an estimated loss in annual revenue from targets of $ 82 million. If this analysis is extended to the entire industry excluding households, the revenue losses are likely to reach as much as $ 2.5 billion. The dissatisfaction with the operation and performance of solar PV projects has almost doubled, from 1.61% in 2019 to 3.13% in 2022, with a tendency to continue to grow in the future.

This study shows that the problems of failures in operation and performance expectations depend on the installed capacity of the plant. Smaller sites exhibited the most variability in power loss and the highest average power loss as a percentage of their total generation capacity. This fact has a special negative impact on the small and medium size PV power plant's prosumers. Smaller ranges in power loss as a percentage of total site capacity were observed in larger site sizes. However, the largest sites tend to exhibit higher average power loss. For example, for sites with less

than 5 MW installed capacity, the amount of max power loss was above 85%, while the average loss was about 4%. The average power loss for the entire range of installed capacity was 3.4%, varying between 5.1% for the PV plants with installed capacity between 10 and 20 MW, and 2.17% for the PV plants with installed capacity between 50 and 100 MW. These power losses bear a heavy revenue burden: for PV plants with an installed capacity above 200 MW, the average drop in expected production has tripled compared to 2019, from 1.1% to 4%, with a tendency to be as much as 6% in 2025. In conclusion, PV plants larger than 200 MW have an economic loss of about $ 4,329 per installed MW on average, with some plants losing as much as $ 12,900 per installed MW, or between $ 1 and $ 2.5 million annually.

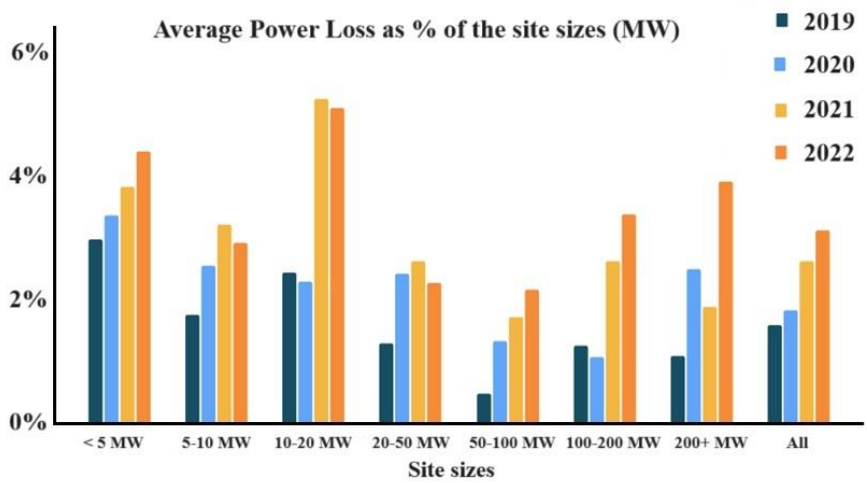


FIG 3. AVERAGE AMOUNT OF POWER LOSS IN % VS. PLANT SIZE COMPARED TO 2019
Source: Global Solar Report (2023).

Data presented in Fig. 3 shows that power loss has significantly increased across all sizes of PV plants since 2019. The average increase in power loss is given in Table 2.

TABLE 2. AVERAGE INCREASE IN POWER LOSS VS. INSTALLED CAPACITY

Installed Capacity (MW)	Average increase in power loss
50 – 100	+ 336 %
100 – 200	+ 168 %
200+	+ 267 %
For all sizes	+ 94 %

Source: Global Solar Report (2023).

Therefore, the analysis concludes that as PV plants become larger and more complex, asset owners and managers should have access to the right tools to manage the health of their sites effectively. Any unexpected deviations from expectations could result in significant financial losses for investors, particularly in the case of private investments. This situation is even worse if the investor is a prosumer who expects to achieve a self-sufficient energy supply and sell excess energy to the local power grid.

Additionally, another recently done study conducted in Spain on the economic

performance of various PV installations, such as single-family houses, multi-family houses, and apartment block housing, provides relevant data on investment and expected energy generation for PV plants (Fuster-Palop, 2023).

This study was done for the small housing community of the app. 3,500 houses in the Mediterranean region which makes it exceptionally reliable for our purposes because it deals with a location with significant solar irradiation. The most important conclusion derived from analyzing multiple load profile scenarios revealed that the potential self-sufficiency of the municipality ranges between 21.9% and 42.5%. In other words, the prosumers who are the largest number of investors and who expect that their PV power plant would supply them with enough electricity for their personal needs, and the excess generated power could be sold on the local electricity market, at most could expect to cover only 42% of their electricity needs. Considering the prices for electricity offtake by the power grid, which is usually not very favorable, the investment could not achieve the expected business outcome. In such cases, the expected payback period of the investment could last between 6.75 and 9.07 years and strongly depends on the capacity of the installed PV plant. The shorter payback period correspondence with the 4.68 kW while the longer payback period was obtained for the 9.2 kW installed PV plan capacity (Fuster-Palop, 2023). This data shows that some mitigation actions should be considered or even taken before reaching a final decision for investments by potential prosumers.

POTENTIAL MITIGATION ACTIONS

Considering the differences between expected and achieved goals for the installed PV power plants, we must strongly consider potential mitigation actions that might improve the outcomes regarding the amount of generated EE and expected financial investment benefits. To be realistic, there are some other well-known obstacles in power generation using RES, in general, due to their stochastic nature. Thus, it is not possible on a long-term basis to exactly predict the amount of available energy sources for power generation, e.g. the amount, direction, and duration of wind for wind power generation, or the amount of solar irradiation, sunlight duration, or the amount of shadowing of the panels due to various unfavorable weather conditions, such as clouds, fog, dust, snow or even rain, or due to other solar obstacles such as local vegetation and artificial constructions around PV power plants. In such cases, some mitigation actions must be taken.

To begin with, PV power plants can only operate during daylight, which means they are unusable during the rest of the day. However, the need for EE is constant throughout the day, and therefore an additional energy source is required to ensure a stable, reliable, and secure EE supply. There are several options available to address this issue, including:

1) Connecting the PV power plant to the local power grid if it is economically feasible,
2) Using another more stable energy source such as a diesel unit, hydropower unit, or similar, and
3) Installing an energy storage unit that can store the generated energy that is not used while the PV power plant is in operation.

Each option requires additional investments, whether it be in the local grid connection, procurement of other generation units, or the procurement and installation of energy storage systems. Each option has its pros and cons that must be considered before making a final investment decision.

Although connecting the PV plant to an existing power grid is a reliable option, it may be expensive, especially if there is no nearby suitable power grid. However, this option provides the opportunity to sell excess electricity generated by the PV plant if allowed. On the other hand, investing in stable energy sources like diesel or small hydropower units requires additional investments. Additionally, the installation, operation, and maintenance costs can be a significant burden for the PV plant owner. Nevertheless, owning a generation unit provides energy independence and security, especially if the cost of connecting to the power grid is too high or not feasible. Finally, investing in additional energy storage units such as batteries could be a reasonable solution as they require lower O&M costs than independent power generation units. However, these storage facilities have a limited number of charging and discharging cycles, and their storage capacity decreases over time due to their limited life expectancy, which varies between 5 and 10 years depending on the producer.

Excess energy generated by PV plants can be saved in multiple ways, including chemically in batteries, mechanically using flywheels or compressed air, and thermally in thermal batteries. Depending on the amount of excess energy and the needs of the consumer, thermal batteries can be a favorable option, especially for industrial customers that require heat in their production process or commercial buildings such as hotels that need heating and/or cooling of their facilities. Thermal energy conservation is also a feasible choice for locations with harsh weather conditions, particularly for areas at high sea levels where the number of sunny days in winter is higher than in lower regions due to the lower height of clouds.

After considering all the points mentioned above, it is more suitable for areas like these to move away from installing solar PV power plants and instead focus on installing solar-thermal power plants. This way, instead of generating electricity, thermal heat can be directly generated using solar energy. This solution is also beneficial for small-scale investors such as households, apartment buildings, or farmers. It is important to note that a significant amount of electricity consumed in a typical household or apartment building is used for heating purposes such as

generating hot water or heating the living or working space.

Small farmers face a similar situation when it comes to meeting their energy demands. They need to heat their animal farms, produce meat and/or milk products, heat their houses, or power any biogas production facilities. Therefore, before investing in a solar PV plant, each investor/prosumer should have a well-defined business plan and strategy outlining their energy needs. Do they require fuel-free electricity or fuel-free heat energy? By carefully defining their needs and potential for a long-term period, they can make the right investment decision, whether it be in solar PV or solar-thermal power plants. Solar-thermal power plants have lower investment costs and easier and lower O&M costs than PV power plants. Furthermore, they come with heat boilers that can act as energy storage devices, generating hot water and eliminating the need for additional storage. This feature improves the quality of the installation, provides additional independence, and improves the return on investment and overall business.

FINAL REMARKS AND CONCLUSIONS

The use of solar power has become an attractive investment opportunity for many investors, including small household owners and larger-scale investors. However, most of them lack knowledge about renewable energy sources and the characteristics, opportunities, and problems with harnessing solar power. Investors need to conduct a thorough techno-economic analysis before investing in solar PV power sources. Without proper analysis and a sound business plan, the project may not generate the expected amount of energy or commercial benefits.

In this paper, two sets of problems have been identified and discussed. The first set of problems, called objective problems, arises from the nature of the PV technology and its development status, which mostly do not depend on human factors. The second set of problems, called subjective concerns, relates to the needs and expectations of the potential investors, e.g., whether they want to become self-sufficient in their electricity needs, become energy producers, or both. Studies show that neither fully self-sufficient EE generation could be achieved, nor expected investment return rate or payback periods could match what is usually presented in the business plants before making final investment decisions. Thus, careful reevaluation of all relevant data must be done with respectful due diligence.

The paper also proposes some potential mitigation actions that may improve the economic parameters of the available investments, such as additionally connecting to the local electricity grid, installing batteries for energy storage, and considering investments shift from PV power plants for EE generation into solar-thermal power plants that primarily generate heat instead of EE.

In conclusion, investors must conduct a thorough analysis before investing in a PV

power plant. They should ask questions about the expected benefits and the quantities of expected energy production. The problems are substantial for the owners and managers of larger PV plants, for which a centralized and standardized system is essential for the PV industry to grow and achieve expected performances reliably.

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OPEN ACCESS ARTICLE

EXPLORING TOURISM DYNAMICS: NORTH MACEDONIA IN REGIONAL CONTEXT

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Abstract

This paper explores the nature of tourism in North Macedonia within the broader regional economic context. By examining its economic impacts, it compares the situation with selected countries in South and Mediterranean Europe, with particular attention to neighboring countries. Utilizing data from 2015 to 2019, it excludes the post-COVID-19 period, which introduced a new environment distinct from the preceding years. The findings not only provide insights into fostering a positive outlook, but also recognize the challenges facing tourism development in North Macedonia within its regional framework. Additionally, the research underscores the importance of enhanced integration among neighboring countries in the region.

Keywords: *Tourism development; North Macedonia; Regional economic environment; Challenges.*

INTRODUCTION

The interplay between regional economic development and the role of tourism has received extensive attention in academic literature (Allan et al., 2017; Calero & Turner, 2020; Dong et al., 2018; Dwyer et al., 2016; Li et al., 2017; Williams, 2016; Yang et al., 2018; Zhang, 2017, and others). Scholars universally acknowledge tourism as a catalyst for regional development in developed countries and as a pivotal driver of economic growth in less-developed ones.

This paper contributes to the existing body of knowledge by delving into the dynamics of tourism in North Macedonia within the broader regional economic landscape. Specifically, it undertakes a comparative analysis with selected countries in South and Mediterranean Europe, with a keen focus on neighboring countries.

Following this introduction, the paper furnishes background material on tourism data pertaining to North Macedonia, accompanied by a comprehensive review of theories and models investigating the role of tourism in economic development. Subsequently, the methodology section outlines the dataset, sampling techniques, and data sources employed in this study. The next section presents a summary of the findings followed

by a detailed discussion thereof. Finally, the paper concludes with key insights, limitations, and recommendations for future research.

BACKGROUND MATERIAL

North Macedonia, with a population of 1,836,713 in 2021 (Statistical Office of the Republic of North Macedonia, online) is a small country. It boasts a GDP per capita of $6,720.9, a 4% GDP growth, 16.2% total unemployment, and 3.2% annual inflation (World Bank, online). In 2019, tourism played a significant role, contributing an estimated $401 million to the economy, with an average of $529 in receipts per tourist (World Data, online). During that year, the country welcomed 1,184,963 tourists, with 63% being foreign visitors who stayed an average of just 2.8 days. Additionally, the tourism sector generated approximately 20,000 jobs in related industries, accounting for about 3% of total employment (Statistical Office of the Republic of North Macedonia, online).

However, this positive trend was interrupted by the COVID-19 pandemic in 2020. The ensuing international travel restrictions resulted in a dramatic decline of 61% in total tourist arrivals, with a staggering 85% loss in international tourism demand. Domestic tourism became predominant, accounting for 85% of total registered overnights, but this shift failed to compensate for the overall losses. Nearly 4,500 jobs in the tourism sector were lost, significantly impacting the broader economy. The government implemented various health and economic measures to mitigate further damage to the tourism industry. As a result, in 2021, there was a gradual recovery in tourism activity compared to 2020, with total arrivals increasing by 51% and total overnights by 36%. Notably, foreign arrivals saw a modest increase of 17%, while foreign overnights witnessed a remarkable surge of 165% (Statistical Office of the Republic of North Macedonia, online).

The onset of the COVID-19 pandemic in 2020 fundamentally altered the tourism landscape, raising numerous unresolved issues and potential development pathways for consideration (Lew et al., 2020). Some countries in South and Mediterranean Europe, such as Montenegro and Greece, experienced severe damage, with total overnights plummeting by 82% and 73%, respectively. However, others, like Albania and Serbia, managed to stage impressive recoveries in early 2021, with total overnights increasing by 98% and 81%, respectively (Petrevska & Andreeski, 2023). Nonetheless, North Macedonia still lags behind the regional average for South and Mediterranean Europe, underscoring the need for financial incentives and coordinated regional promotional efforts.

LITERATURE REVIEW

Scholars have shown considerable interest in understanding the relationship between regional economic development and tourism. Recognizing tourism's significance as a catalyst for regional growth, many researchers have proposed and applied various

models to assess its role both theoretically and empirically. Among these models are the Tourism Satellite Account (UNSC et al., 2008), the gravity model (Park & Jang, 2014; Santana-Gallego et al., 2016), the input-output model (Van Wyk et al., 2015; Williams, 2016), the social accounting matrix based model (Wagner, 1997; Zhang, 2002), computable general equilibrium model (Allan et al., 2017; Dong et al., 2018; Dwyer et al., 2016; Li et al., 2017), time-series, and structural vector autoregressive approaches (Andraz et al., 2015; Cashin et al., 2014), among others.

While these concepts, theories, models, and methodologies provide various perspectives for assessing tourism's impact and measuring its contribution, they primarily focus on two main areas: the impact of tourism on economic development (Andraz et al., 2015; Ma et al., 2018; Sharpley & Telfer, 2014) and regional economic impacts and evolution (Meekes et al., 2017; Mellon & Bramwell, 2016; Yang et al., 2018).

METHODOLOGY

To thoroughly understand the dynamics of tourism growth in North Macedonia within the broader regional economic context, this study analyzes, compares, and interprets stylized tourism data from selected countries in South and Mediterranean Europe. The dataset spans from 2015 to 2019, purposefully excluding the disruptive effects of the COVID-19 pandemic. Data are gathered from various secondary sources, as well as national and international documents, for North Macedonia and specific countries including Albania, Croatia, Greece, Montenegro, Serbia, and Slovenia. Additionally, desk research is conducted to review literature on regional economic development and the significance of tourism. This comprehensive approach forms a robust basis for systematic analysis and drawing conclusions.

FINDINGS AND DISCUSSION

The stylized facts presented in Table 1 shed light on the dynamics of tourism, specifically the total number of overnights, and chain indexes for the period 2015-2019. The aim is to understand the nature of tourism in North Macedonia and compare it with South and Mediterranean Europe, focusing on Albania, Croatia, Greece, Montenegro, Serbia, and Slovenia.

Analyzing Table 1, it becomes evident that Slovenia experienced the most substantial cumulative increase in total overnights during 2015-2019, with a notable 54% surge. Following closely is Serbia, which witnessed a 51% increase, while Croatia exhibited the lowest growth rate at 28%. North Macedonia recorded a 36% increase, slightly below the average increase in total overnights for the entire sample (39%). This suggests a relatively moderate pace of tourism development compared to the average of selected countries from South and Mediterranean Europe.

TABLE 1. TOTAL OVERNIGHTS AND CHAIN INDEXES IN SELECTED COUNTRIES IN SOUTH AND MEDITERRANEAN EUROPE, 2015-2019

Country/Year	2015	2016	2017	2018	2019
Albania	:	:	:	3,074,657	3,253,419
				100	106
aCroatia	71,339,000	77,824,114	86,094,847	89,567,653	91,178,083
	100	109	111	104	102
Greece	106,064,266	110,020,042	119,009,014	142,940,411	143,594,467
	100	104	108	120	100
Montenegro	11,054,947	11,250,005	11,953,316	12,930,334	14,455,920
	100	102	106	108	112
North Macedonia	2,394,205	2,461,160	2,775,152	3,176,808	3,262,398
	100	103	113	114	103
Serbia	6,651,852	7,533,739	8,325,144	9,336,103	10,073,299
	100	113	111	112	108
Slovenia	10,224,207	11,057,731	12,460,084	15,694,705	15,758,691
	100	108	113	126	100

Source: Croatian Bureau of Statistics, Eurostat, State Statistical Office of Albania, State Statistical Office of the Republic of North Macedonia, Statistical Office of Montenegro, Statistical Office of Serbia, Statistical Office of Slovenia, World Bank (online data).

TABLE 2. TOURISM INCOME ($000) AND SHARE IN TOTAL EXPORTS (%) IN SELECTED COUNTRIES IN SOUTH AND MEDITERRANEAN EUROPE, 2015-2019

Country/Year		2015	2016	2017	2018	2019
Albania	Tourism income	1,499,000	1,693,000	1,943,000	2,186,000	2,329,000
	% of total exports	51.96	52.94	49.47	48.20	50.97
Croatia	Tourism income	8,022,000	9,028,000	10,320,000	11,127,000	11,753,000
	% of total exports	35.69	37.32	37.60	36.94	37.94
Greece	Tourism income	15,665,000	14,727,000	16,875,000	18,821,000	20,276,000
	% of total exports	28.02	27.88	27.30	26.38	28.33
Montenegro	Tourism income	903,000	933,000	1,067,000	1,171,000	1,224,000
	% of total exports	55.27	54.81	54.81	52.16	52.64
North Macedonia	Tourism income	265,000	280,000	327,000	382,000	396,000
	% of total exports	5.46	5.20	5.30	5.08	5.14
Serbia	Tourism income	1,048,000	1,151,000	1,345,000	1,547,000	1,604,000
	% of total exports	7.58	7.60	7.80	7.77	7.65
Slovenia	Tourism income	2,399,000	2,517,500	2,869,000	3,181,100	3,179,800
	% of total exports	7.82	7.82	7.55	7.35	7.36

Source: World Bank (online data).

Table 2 offers insights into the tourism income of selected countries from South and Mediterranean Europe for 2015-2019, along with their respective shares in total exports. Montenegro emerges with the largest share in exports among the selected countries. Notably, Greece leads in tourism income, surpassing $20 billion in 2019, followed by Croatia with nearly $12 billion. Conversely, North Macedonia exhibits the lowest participation in exports, averaging 5.24% for the period 2015-2019. However, its proximity to neighboring countries with significantly larger tourism incomes and substantial contributions to total exports suggests potential for North Macedonia to collaborate on regional tourism initiatives.

Seasonality often poses challenges to tourism development. Table 3 presents summarized statistical data, including the Gini and Theil indexes, commonly used to measure seasonality in tourism. Notably, the calculated data (2011-2019) reveal low seasonality with negligible impacts on tourism development in Albania, Bulgaria, and Serbia, important neighboring countries selected from South and Mediterranean Europe. Intriguingly, North Macedonia also exhibits low seasonality, as indicated in previous studies (Petrevska, 2013, 2014).

TABLE 3. SEASONALITY INDICATORS FOR SELECTED INCOMING COUNTRIES FROM SOUTH AND MEDITERRANEAN EUROPE

Indicator/Country	Gini	Theil	Correlation Gini vs. Theil
Albania	0.111028	0.111028	0.111028
Bulgaria	0.101895	0.101895	0.101895
Serbia	0.113792	0.113792	0.113792

Note: Calculations for period 2011-2019.

Further analysis of Table 3 reveals that Bulgaria exhibits the lowest average seasonality indexes, indicating greater variation in visitor statistics compared to Albania and Serbia. Moreover, the correlation coefficients between the seasonality indicators across years suggest minimal differences in seasonality among the selected incoming countries. Consequently, the low tourism seasonality observed in neighboring countries (Albania, Bulgaria, and Serbia) implies a continuous influx of visitors to North Macedonia throughout the year. This underscores the potential for intensified promotional efforts to increase North Macedonia's modest share of total international overnights.

CONCLUSION

This research delved into the regional aspects concerning tourism development and the regional economy. It examined the nature of tourism in North Macedonia within the broader context of regional economic growth and development, comparing it with the tourism development of Albania, Croatia, Greece, Montenegro, Serbia, and Slovenia as selected countries from South and Mediterranean Europe. Over the period

of 2015-2019, North Macedonia exhibited the lowest average cumulative increase compared to the sample. This is further evidenced by its lowest participation in total exports among the neighboring countries in the sample. Consequently, opportunities arise for North Macedonia to explore new avenues in creating a joint regional tourism product.

Additionally, the study addressed seasonality as a constraining factor for tourism development. Analysis of inbound tourism from Albania, Bulgaria, and Serbia revealed low seasonality, indicating a consistent influx of tourists throughout the year. This presents a favorable starting point for more aggressive regional tourism promotion efforts.

Overall, the research findings offer practical insights for national tourism policymakers and propose conceptual frameworks for identifying and establishing a comprehensive regional tourism concept spanning several countries in South and Mediterranean Europe. Therefore, the study could aid destination marketers in recognizing key factors for developing a specific regional tourism product and enhancing North Macedonia's current modest tourism development.

However, certain limitations were encountered during the research, which could serve as valuable starting points for future endeavors. Firstly, the study focused on a relatively narrow set of indicators related to tourism development and economic growth, suggesting the inclusion of additional indicators to better grasp tourism's impacts in the regional context. Secondly, while the study treated international tourism as a form of international trade, future research could delve deeper into trade theory and its relationship with tourism at both national and regional levels. Thirdly, a multidisciplinary approach was lacking in drawing more nuanced conclusions, indicating the need for future research to incorporate system analysis within the framework of regional economics.

Nevertheless, the findings underscore the need for strategic direction in guiding tourism development in North Macedonia towards fostering regional economic growth. This entails adopting diverse approaches to foster systematic collaboration with other regional countries, thereby contributing to the strengthening of regional economic development.

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