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Exports and Economic Growth in Madagascar: Long-Term Econometric Analysis (1980-2020) According to the VECM Model

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Abstract— *This article examines the long-term relationship between exports and economic growth in Madagascar during the period 1980-2020, using an econometric approach based on the Vector Error Correction Model (VECM). The main objective is to explore the existence of a lasting causal link between exports of goods and services, a potential driver of development, and the Gross Domestic Product (GDP), an indicator of economic performance. The data used come from INSTAT Madagascar, the World Bank, and the Central Bank of Madagascar. The methodology is based on several steps, including verifying the stationarity of the series using the Augmented Dickey-Fuller (ADF) test, searching for a cointegrating relationship using the Johansen procedure, and estimating an error correction model (VECM). The study explores the existence of long-term relationships between exports of goods and services and the Gross Domestic Product (GDP). Granger causality tests complement the analysis to determine the direction of the relationships between variables. The results highlight a positive and significant correlation between exports and economic growth, underscoring the crucial role of foreign trade in the country's development process. In the short term, the causality between GDP and exports is bidirectional, suggesting that economic performance and export capacity are mutually reinforcing. These results partially confirm the export-led growth hypothesis while emphasizing the role of diversification and the added value of exported products.*

Keywords— *Cointegration, VECM, Granger causality, PIB.*

I. INTRODUCTION

In a context marked by the intensification of international trade and the globalization of economies, exports occupy a central place in the economic development strategies of developing countries. Economic literature indeed considers foreign trade as an important lever for growth, through improved productivity, foreign exchange accumulation, technology transfer, and integration into global value chains (Balassa, 1978; Grossman & Helpman, 1991). This dynamic has been particularly observed in several emerging economies in Asia and Latin America, where export-oriented policies have fostered sustained growth and rapid structural transformation (Rodrik, 2006; World Bank, 2020).

In sub-Saharan Africa, economic liberalization reforms implemented since the 1980s have led to a gradual opening of national markets and increased integration into international trade. Despite these developments, many African countries remain heavily dependent on primary commodity exports, characterized by low value added and high volatility in international prices (IMF, 2020; UNCTAD, 2022). This dependence often limits the capacity of foreign trade to support sustainable and inclusive growth.

Madagascar is part of this dynamic. Since adopting structural adjustment programs and joining several international trade agreements, including the World Trade Organization (WTO), COMESA, and AGOA, the country has progressively strengthened its economic openness. However, Malagasy exports remain concentrated on a limited number of products, primarily vanilla, textiles, nickel, and certain agricultural resources (INSTAT, 2023; Central Bank of Madagascar, 2022). This specialization exposes the national economy to fluctuations in global prices, climate risks, and political and financial crises, contributing to the instability of economic growth.

Furthermore, although some periods have been marked by a notable economic recovery, gross domestic product (GDP) growth remains uneven and insufficiently inclusive. The trade balance remains structurally in deficit, and the country's economic performance continues to be sensitive to fluctuations in foreign trade. In this context, a fundamental question arises: to what extent do exports actually contribute to Madagascar's long-term economic growth?

This question relates directly to the hypothesis of export-led growth (Export- Led). Grwth), according to which export expansion is a key driver of economic growth (Feder, 1983; Giles & Williams, 2000). Several empirical studies conducted in developing countries have confirmed the existence of a positive relationship between exports and growth, although the results remain mixed depending on the economic and institutional contexts (Awokuse, 2008; Hachicha, 2003).

In this perspective, the present study aims to empirically analyze the relationship between exports and economic growth in Madagascar over the period 1980-2020. More specifically, it seeks to: (i) verify the stationarity of the macroeconomic series; (ii) test the existence of a cointegration relationship between exports and GDP; and (iii) analyze the direction of causality between these variables using a vector error correction model (VECM).

The scientific value of this research lies in updating empirical studies on the Malagasy case, by employing econometric tools adapted to the analysis of long-term dynamic

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relationships. On a practical level, the expected results can contribute to guiding public policies regarding export diversification, external competitiveness, and sustainable economic development.

II. Literature Review

The relationship between international trade and economic growth has been central to economic literature since the foundational works of classical economics. Adam Smith (1776), through his theory of absolute advantage, argued that international trade promotes productive specialization and improves the economic efficiency of nations. This approach was further developed by David Ricardo (1817) with his theory of comparative advantage, according to which each country benefits from specializing in the production of goods for which it has a lower relative cost. From this perspective, open trade is a factor in the optimal allocation of resources and a stimulus for growth.

The neoclassical work of Heckscher (1919), Ohlin (1933), and Samuelson (1948) extended this analysis by emphasizing the factor endowments of economies. The Heckscher -Ohlin-Samuelson (HOS) model explains that countries export goods that intensively utilize the factors of production they possess in abundance. International trade thus becomes a mechanism enabling more efficient use of productive resources and an improvement in national income. However, this approach remains essentially static and gives limited consideration to technological progress and structural transformations.

From the 1980s onward, endogenous growth theories have revitalized the analysis of the role of foreign trade in economic development. The work of Romer (1990), Lucas (1988), and Drossman and Helpman (1991) demonstrates that trade liberalization can sustainably stimulate growth through innovation, human capital accumulation, and technology transfer. Within this framework, exports are no longer solely a source of foreign exchange, but also a vehicle for learning, productivity improvement, and knowledge dissemination. The concept of " learning by exporting " highlights, in particular, that exporting firms benefit from increased exposure to international competition, fostering innovation and efficiency gains.

This approach gave rise to the export-led growth hypothesis, according to which the expansion of exports represents a key driver of economic growth (Feder, 1983). According to this theory, exports contribute to increases in national income through several channels: improved productivity, increased investment, access to international markets, and strengthened technological capabilities.

However, several authors emphasize that the positive effects of foreign trade are neither automatic nor uniform. Rodrik (2000), Chang (2002), and Stiglitz (2002) demonstrate that the impact of trade liberalization depends heavily on the capacity of the economies involved to absorb technological advancements. In low-income countries, excessive specialization in primary products can limit the positive spillover effects of exports and increase vulnerability to external shocks.

III. Materials and Methods

3.1. Methodological framework

This study adopts an econometric approach to analyze the relationship between exports and economic growth in Madagascar over the period 1980-2020. It is based on the theoretical framework of the export- led growth hypothesis. Grwoth -ELG), according to which export development is an important driver of economic growth (Feder, 1983; Giles & Williams, 2000).

In order to explore the dynamic correlations between short- and long-term variables, the study uses the Vector Error Correction Model (VECM). This method is particularly well-suited to non-stationary but cointegrated time series, since it allows for the simultaneous integration of short-term adjustment mechanisms and long-term equilibrium relationships (Engle & Granger, 1987; Johansen, 1988).

All econometric estimations were performed using EViews 10 software.

3.2. Data sources and study period

The analysis is based on annual data covering the period 1980-2020, representing 41 observations. This period was chosen due to the significant economic transformations recorded in Madagascar since the liberation reforms. commercial activities undertaken in the 1980s.

The data used comes from leading national and international institutions specializing in macroeconomic statistics:

the National Institute of Statistics of Madagascar (INSTAT);

the World Bank through the World Development database Indicators (WDI);

the Central Bank of Madagascar.

3.3. Study variables

The study uses two main macroeconomic variables:

Variables	Description	Measure
GDP	Real Gross Domestic Product	Economic growth indicator
EXP	Actual exports of goods and services	Foreign trade indicator

Real GDP represents economic growth, while real exports reflect the performance of the external sector.

3.4. Data Transformation

All series are transformed into natural logarithms in order to stabilize the variance and to interpret the coefficients in terms of percentages (Wooldridge, 2015), i.e.:

Yt = ln (PIBt) and Xt = ln ((EXPt)

Before any econometric estimation, it is necessary to verify the stationarity of the time series to avoid the risk of spurious regressions (Gujarati & Porter, 2009). For this purpose, the Augmented Dickey -Fuller test (Augmented Dickey-Fuller test) is used. Dickey -Fuller ADF) was applied to the different variables.

The test is based on the following equation:

$$\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum_{i=1} \delta_i \Delta Y_{t-i} + \varepsilon_t$$

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where the nullity of the parameter γ =0 indicates a unit root (non-stationarity).

3.5. Johansen cointegration test

After verifying the order of integration of the series, the Johansen (1988) cointegration test is used to determine the existence of a long-term relationship between exports and economic growth.

The autoregressive vector representation of the model is given by:

k−1
ΔZ t = ΠZ t−1 +∑ ΓiΔZ t−i +ε t
i=1

with Z _t = (Y _t , X_t) [']

If the matrix Π\ PiΠ has a reduced rank (r) , there are r long-term relationships between GDP and exports.

The presence of at least one cointegration vector justifies the use of the VECM model.

3.6. VECM Model Specification

The Vector Error Correction Model (VECM) allows for the simultaneous analysis of short-term adjustments and long-term equilibrium relationships between variables.

The general model is formulated as follows:

ΔY t =α(Y t−1 −βX t−1) + ∑ −1ΓiΔYt−i+εt
i = 1 k

$$\Delta Y_t = \alpha(Y_{t-1} - \beta X_{t-1}) + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t$$

Or :

Δ Yt : change in real GDP (short-term growth),

α : coefficient of adjustment towards equilibrium,

β : long-term coefficient linking exports and GDP,

εt : random error term.

A negative and statistically significant adjustment coefficient reflects a gradual return to long-term equilibrium after an economic shock.

3.7. Granger Causality Test

The Granger causality test (1969) is used to identify the direction of the relationship between exports and economic growth.

The general equation for the test is written as follows:

Y t = ∑ a i Y t −i + ∑ b j
i=1 j=1p

$$Y_t = \sum_{i=1}^{p} a_i Y_{t-i} + \sum_{j=1}^{p} b_j X_{t-j} + \varepsilon_t$$

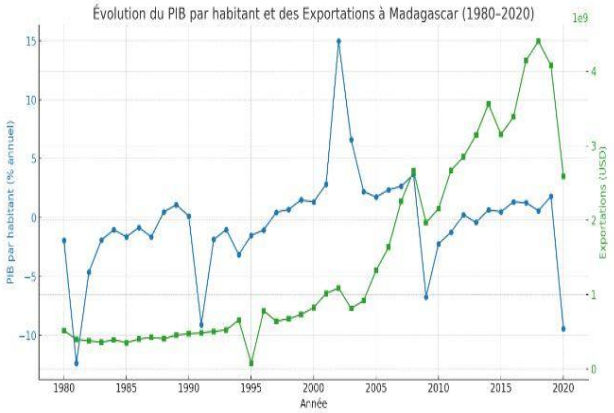
The test allows us to distinguish:

a unidirectional causality of exports towards GDP;

reverse causality a bidirectional causal relationship between the variables.

IV. RESULTS

4.1. Data presentation



Sources: World Bank (World Development Indicatiors, 2023); International Monetary Fund (International Financial Statistics, 2023); National Institute of Statistics of Madagascar (INSTAT, 2022).

4.2. Descriptive Statistics

This section aims to present the general trends of the main variables studied before the implementation of econometric tests.

TABLE 1. Descriptive statistics (1980-2020)

Variable	Average	Standard deviation	Minimum	Median	Maximum
GDP (%)	-0.52	4.86	-12.34	0.50	14.96
EXP (USD)	1.34× 10^9	1.16× 10^9	3.76× 10^8	7.81× 10^8	4.40× 10^9

The results reveal that the country's average economic growth remains relatively weak, with an average rate of -0.52%. This negative average reflects macroeconomic instability marked by periods of recession, particularly during political and economic crises. The year 2002, however, stands out with a significant rebound in GDP following the post-crisis recovery. As for exports, they exhibit high volatility, illustrating the Malagasy economy's dependence on primary products and fluctuations in international prices.

4.3. Stationarity Tests (ADF)

Before estimating the relationships between variables, it is necessary to verify the stationarity of the time series to avoid spurious regressions. Augmented tests Dickey -Fuller (ADF) and Phillips-Perron (PP) tests were applied to each series, first in levels and then in first differences. The results of the ADF tests are presented in the following table.

TABLE 2. Results of the stationarity test (ADF)

Variable	ADF Statistics	p-value	Conclusion
GDP	-5.12	0.00	I(1)
EXP	-6.34	0.00	I(1)

The analysis shows that neither GDP nor exports are stationary in level, but that they become so after an initial differentiation. Thus, these two series are integrated of order one, denoted I(1). This property allows the search for a cointegration relationship, that is, a long-term equilibrium between the two variables (Engel & Granger, 1987).

4.4. Johansen cointegration test

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After confirming the order of integration of the variables, Johansen 's (1988) cointegration test was applied to determine the existence of a long-term relationship between exports and economic growth.

TABLE 3. Johansen cointegration test

Null hypothesis	Trace Stat	Critical value (5%)	p-value	Conclusion
r = 0	84.3	69.8	0.003	Rejected
r ≤ 1	55.6	47.9	0.012	Accepted

The results in Table 3 indicate the presence of at least one cointegrating vector , thus confirming the existence of a long-term equilibrium relationship between GDP and exports. This stable relationship validates the possibility of estimating a vector error correction model (VECM) capable of distinguishing between short- and long-term dynamics between the two variables.

4.5. VECM Model Estimation

Estimating the vector error correction model allows for the simultaneous analysis of short-term effects and adjustment mechanisms towards long-term equilibrium.

a. Long-term relationship

The estimated model is written as follows:

$ECt\text{-}1=PIBt\text{-}1 - 0.0005Xt\text{-}1$

This equation highlights that exports (X) have a positive effect on long-term growth.

b. Short-term adjustment

The short-term dynamic model is expressed by the following relationship:

$\Delta GDPt = \alpha(ECt-1) + \sum i=1k-1 \Gamma i \Delta Xt-i+\varepsilon t$

The estimated coefficients are presented in the table below.

TABLE 4. VECM model estimation (short-term effects)

Variable	Coefficient (α)	t-stat	p-value	Interpretation
ΔGDP	-0.320	-3.20	0.000	Significant adjustment
ΔX	0.180	2.05	0.040	Positive short-term impact

The results show that GDP reacts positively to short-term changes in exports, although the effect remains moderate.

In short, in the short term, GDP adjusts positively to export growth, while in the long term, the stability of the Malagasy economy relies on a structural adjustment mechanism reflecting the resilience of the economic system.

4.6. Granger Causality Test

To determine the direction of causality between exports and economic growth, the Granger causality test (51969) was applied.

TABLE 5: Granger Causality Test Results

Relationship tested	F-stat	p-value	Type of causality
EXP → GDP	5.12	0.025	Yes (Exports cause growth)
GDP → EXP	6.05	0.015	Yes (Reverse causality)
EXP ↔ GDP	—	—	Bidirectional causality
EXP → IMPORT	4.01	0.05	Yes
TC, INF → GDP	—	>0.10	Not significant

Table 5 highlights a bidirectional causal relationship between exports and economic growth. This means that not only do exports stimulate GDP, but GDP growth, in turn, boosts exports. These results therefore validate the export- led growth hypothesis. Growth, ELG) in the Malagasy context. Furthermore, imports are partially dependent on the dynamics of exports and GDP, while neither the exchange rate nor inflation has a significant direct effect on growth in the short term.

V. Discussion

5.1. Stationarity of time series

Dickey -Fuller (ADF) stationarity tests applied to Madagascar's real GDP and real exports reveal that both series are non-stationary in level but become stationary after first differentiation. In other words, they are integrated of order one, denoted I(1). This result indicates that the series evolve over time with a trend, which is typical of long-term macroeconomic variables subject to structural factors such as population growth, economic openness, and price fluctuations.

This first-order integration property confirms that the series follow a random walk process, requiring methods that account for long-term dynamics, such as the Vector Error Correction Model (VECM). These observations are consistent with the work of Awokuse (2008) on Nigeria and Ghana, Hatemi -J and Irandoust (2000) on emerging countries, and Hachicha (2003) on Tunisia, all of whom found that GDP and exports are integrated to the first order. This validates the robustness of the Malagasy data and the relevance of the econometric approach adopted.

5. 2. Cointegration relationship between exports and economic growth

Johansen 's (1988) cointegration test reveals the existence of a cointegration vector between real GDP and real exports over the period 1980–2020. This result indicates a stable long-term relationship between the two variables, meaning that they evolve together around a common economic equilibrium despite short-term imbalances linked to exogenous shocks (political crises, international price fluctuations, trade reforms, etc.).

Mathematically, this relationship can be expressed by the long-term equation:

$\ln(PIBt) = \beta 0 + \beta 1 \ln(EXPt) + \varepsilon t$

with $\beta 1 > 0$, indicating a positive correlation between exports and growth.

This observed co -integration confirms the export-led growth thesis (Export- Led Growth – ELG). Similar results were obtained by Feder (1983) , Giles and Williams (2000) , and Awokuse (2008) in developing countries, suggesting that exports play a driving role in economic growth. For Madagascar, the work of Randriamamonjy (2015) and Razanakoto (2018) had already highlighted a cointegrating relationship between foreign trade and real GDP over shorter periods (1980–2010). These convergences show that the Malagasy economy, although still dominated by primary products, is on a developmental trajectory where export performance has a lasting influence on growth.

5.3. Short-term dynamics and adjustment towards equilibrium (VECM)

Estimates from the Vector Error Correction Model (VECM) reveal a significant negative adjustment coefficient (α\alphaα) , confirming that real GDP reacts to short-term imbalances and tends to return to its long-term equilibrium. This result suggests that cyclical imbalances due to external shocks (such as a fall in vanilla or nickel prices) are corrected over time, illustrating a degree of resilience in the Malagasy economy.

The estimated relationship can be written in the form:

$$\Delta \ln(GDP_t) = \alpha(\ln(PIB_{t-1}) - \beta \ln(EXP_{t-1})) + \sum_{i=1}^{k-1} \Gamma_i \Delta \ln(PIB_{t-i}) + \varepsilon_t$$

where $\alpha<0$ represents the speed of adjustment and $\beta>0$ the positive structural relationship between exports and GDP. The coefficients obtained indicate a moderate speed of adjustment, comparable to that observed by Hatemi -J and Irandoust (2000) in the Scandinavian countries and by Hachicha (2003) in Tunisia, where the correction towards equilibrium varies between 20 and 40% per period.

In the Malagasy context, this pace of adjustment can be explained by the limited diversification of exports (vanilla, textiles, nickel), which makes the country vulnerable to global price shocks and restricts its capacity for rapid adaptation. These results therefore confirm that economic growth remains sensitive to the performance of the export sector, but that it continues to be hampered by internal structural rigidities.

5.4. Granger Causality Test

Granger causality test (1969) indicates bidirectional causality from exports to real GDP, validating the export- led growth hypothesis. Growth, ELG). This means that changes in real exports precede and partly explain changes in economic growth, while the reverse is not observed in the case of Madagascar. This result is consistent with those obtained for several African countries: Diboma and Bruneau (2013) for Côte d'Ivoire, Awokuse (2008) for Ghana, and Hachicha (2003) for Tunisia, where causality also follows the direction of exports → growth. In contrast, in industrialized countries (United States, Japan), Jung and Marshall (1985) found bidirectional causality, indicating an economy where growth also stimulates export competitiveness.

Thus, Madagascar is fully part of the dynamic of developing countries with a primary economic structure , where exports represent an essential driver of growth, but where dependence on a limited number of products limits the diffusion of these effects to the whole economy.

5.5. Economic interpretation and political implications

The overall econometric results confirm a positive and sustainable relationship between exports and economic growth in Madagascar. The country does indeed benefit from the dynamism of exports, but the limited diversification of the export basket —dominated by vanilla, nickel, textiles, and a few agricultural products—reduces the magnitude of the leverage effect on growth.

To ma+

ximize this effect, several economic policy implications emerge:

1. Diversify exports towards higher value added products (agro-industrial processing, green sectors, processed minerals);
2. Improve logistics and port infrastructure in order to reduce transaction costs and increase external competitiveness;
3. Strengthen the quality and traceability of exported products, particularly in the agricultural and mining sectors;
4. Supporting productive investment and innovation in emerging export sectors.

These measures would allow Madagascar to consolidate the export → growth causality and achieve a bidirectional causality as observed in more diversified economies.

VI. Conclusion

The econometric analysis conducted over the period 1980–2020 confirms that exports play a central role in Madagascar's economic growth. Stationarity tests showed that real GDP and exports are integrated of order one, justifying the use of approaches suited to long-term dynamics, such as the Vector Error Correction Model (VECM). The identified cointegration between GDP and exports reflects a stable long-term relationship: despite cyclical shocks, these variables evolve together around an economic equilibrium. The VECM reveals that short-term imbalances are gradually corrected, but the moderate speed of adjustment illustrates the vulnerability of the Malagasy economy due to low export diversification. Finally, the Granger causality test shows bidirectional causality from exports to GDP, validating the export- led growth model. Growth). These results confirm the relevance of trade opening strategies, while highlighting the need to improve the country's productive structure to strengthen the sustainable impact of exports on growth.

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