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The Long-Term Relationship Between Major Macroeconomic Variables and Peruvian Stock Market Performance: 2003-2023

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Villalobos Gonzales, Maycohol Jampiere

Asesor(es):
Bringas Arboccó, Paul Allan

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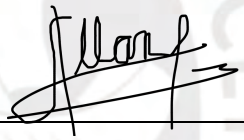
DNI: 07760022	Firma 
ORCID: 0000-0003-2434-8776	

Dedication

This work is dedicated first to God because He has been my main support in every moment. I know that without His help and guidance, this achievement would not have been possible. I also dedicate it to my parents, whose love, effort, and sacrifices have made me who I am.

Philippians 4:13
“I can do all things through Him who strengthens me.”

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Resumen

En esta investigación se analiza cómo variables macroeconómicas tales como el PIB, tasas de interés, PEN/USD y precio del cobre se relacionan con la Bolsa de Valores de Lima (BVL) en el periodo 2003-2023. Para esto se aplicó un modelo de corrección de errores vectoriales (VECM). Los resultados muestran que el PIB y el precio del cobre tienen un efecto positivo sobre la BVL, lo que refleja la gran dependencia de la economía peruana de la minería. En cambio, las tasas de interés presentan una relación negativa. El tipo de cambio, por su parte, no resultó significativo en el largo plazo. Además, con las funciones impulso-respuesta (IRF) se observó que existen reacciones rápidas en el corto plazo, aunque estas no siempre son permanentes. Esto ayuda a confirmar la relación de largo plazo y muestra cierta capacidad de la BVL para enfrentar shocks externos. Se aplicaron también pruebas de ruptura estructural (CUSUM y Bai-Perron) que señalaron cambios importantes en los datos, asociados a hechos como la crisis subprime, la caída de los precios del cobre entre 2010 y 2016, y la pandemia del 2020. A pesar de estos eventos, las relaciones de largo plazo se mantuvieron estables, lo cual da confianza en el modelo utilizado. En concreto, los hallazgos resaltan la importancia de mantener políticas económicas estables y la necesidad de diversificación productiva para reducir riesgos. Esto puede servir como referencia tanto para inversionistas como para empresas y hacedores de política en el Perú.

Palabras clave: Economía peruana, Bolsa de Valores de Lima, Macroeconomía, Precio del Cobre, VECM.

Abstract

This research investigates the cointegration among some key macroeconomic variables (GDP, PEN/USD, copper prices, policy rate) and the Peruvian stock market performance (BVL) during the period 2003–2023. By estimating a Vector Error Correction Model (VECM), this research finds various statistically significant relationships over time in accordance with economic theory. Both GDP and copper prices show a positive association with BVL , reinforcing the heavily mining reliant economy of Peru, while interest rates possess a negative relationship. The PEN/USD however is not found to be statistically significant over time. In addition to these findings, Impulse Response Functions (IRFs) examine the short-run dynamics among these variables and are estimated on their own to observe short run adjustments to macroeconomic shocks. We find evidence from the IRF results that the VECM is supported by both immediate and temporary impulses to macroeconomic shocks which justify the long run relationships found. Furthermore, structural break tests (CUSUM and Bai-Perron) are employed as a benchmark to verify the stationarity of the fdata in addition to assessing how much structural change impacted the significance and stability of the VECM. The Bai-Perron and CUSUM results showed clear structural breaks at some important moments of the study period. These breaks were linked to shocks such as the 2008 financial crisis, the fall of copper prices between 2010 and 2016, and the COVID-19 pandemic. However, the long-run relationships stayed stable, which means that even with these shocks, the Peruvian economy and the BVL kept reacting in the way we could expect over time. Ultimately, these findings call for greater macroeconomic stability and diversification to prevent any overwhelming impacts on the markets while providing insight for investors, companies and policymakers all operating within Peru.

Keywords: Peruvian Economy, Stock Market, Macroeconomics, Copper Prices, VECM .

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Introduction

A stock market index shows not only the performance of the traded firms, but it also reacts to big macroeconomic factors that can change the market in a strong way. Because of this, both domestic and international variables like commodity prices, gross domestic product (GDP), employment rate, policy rates, inflation, and exchange rates can show an important role in how prices move in the capital markets. In the case of Peru, these variables are especially important because the economy depends a lot on the mining sector. Metals like copper, silver, and zinc give a big contribution to the Peruvian economy every year. According to the Ministry of Energy and Mines (2023), mining represented about 16 percent of national GDP between 2017 and 2022. This shows how important mineral exports are for growth and for the stock market performance

Macroeconomic variables affect stock values in different ways. For example, when GDP grows, stock prices usually go up, because companies earn more and investors feel more confident. On the other side, when interest rates rise, they reduce company profits and make investors less willing to take risks, so stock values can fall. Also, if the domestic currency gets stronger, exporters may lose competitiveness abroad, and this affects the stock prices of the companies listed. Other studies have already looked at these relations, checking how variables like commodity prices, GDP, inflation, broad money supply (M3), and exchange rates affect financial markets (Bekhet & Mugableh, 2012).

The years between 2003 and 2023 are a special period to study these relations because there were several global events that impacted emerging countries like Peru. The most important ones were the subprime crisis and the pandemic in 2008 and 2020, respectively. The subprime crisis caused a deep global recession, less international trade, and falling asset prices, and this affected countries that depend a lot on exports, like Peru. Later, the pandemic in 2020 produced one of the biggest economic crises in modern times, and Peru's GDP fell by 11.1 percent (INEI, 2020). These shocks created strong volatility and lower investor confidence.

Another key moment was the long decline in copper prices from 2013 to 2018. This fall was mostly because of oversupply and weaker demand from China, which is the main copper consumer in the world. These episodes show how much Peru is

exposed to global changes and why it is necessary to understand better how macroeconomic conditions and the Peruvian stock market index move together, especially in the long-term.

With this background, the major goal of this investigation is to study how these key macroeconomic variables are related to the Peruvian stock market performance in the period 2003-2023, a period that had strong global financial events.

The specific objectives are:

- To identify and explain any stable long-run relations among the BVL and the macroeconomic variables.
- To analyze short-run dynamics to compare and complement the long-term results, and especially during the mentioned shocks.
- To use structural break tests and stability checks to study how strong these relations are in periods of stress like the subprime crisis and the pandemic crisis in 2020.

To reach these objectives, the study applies a clear methodological framework with modern econometric tools. The central model is the Vector Error Correction Model (VECM), which helps to estimate long-term equilibrium among variables that are cointegrated. Also, impulse-response functions are used to study short-term dynamics, and structural break tests are implemented to check if the relations stay stable in periods of turbulence.

The document follows a clear order. It begins with a examination of the existing literature and then explains the theoretical framework that supports the study. Next, it presents the hypotheses, followed by the description of the data and the main descriptive statistics. After that, the methodology and the econometric model are introduced. The following part examines the results. In the end, the document closes with the main conclusions, their implications, some recommendations, and possible lines for future research.

1. Literature Review

It is very important to understand how macroeconomic variables and the stock market are connected, especially in countries like Peru that are still developing. Since the Peruvian economy depends a lot on commodities, global shocks usually hit harder and create special situations in its capital market. Because of that, many researchers have studied this topic before, and their findings help to decide which variables are important for this study.

For Peru, a big part of the literature focuses on the role of mining. Martínez (2012), for example, looked at how international copper and silver prices affect the mining companies in the Lima Stock Exchange. He found a strong relation, which means that the Peruvian market is very sensitive to external demand. This shows how exposed the country is to global commodity cycles.

Another work by Zevallos, Villarreal, Del Carpio, and Abbara (2017) used the CoVaR model to analyze how metal price volatility influences risk. They showed that changes in the prices of metals clearly affect the risk of the General Index of the Lima Stock Exchange (IGBVL). This is important for risk management. At the same time, they found that gold and silver only had a moderate impact, while some international markets could even affect Peru's stock market risk more strongly.

Estrada and Ramos (2013) studied the effect of copper price shocks with an SVAR model. Their results confirmed that copper was the most relevant metal. They also found that demand shocks, like China consuming more or the need to build up inventories, had a strong influence on stock returns. In contrast, supply shocks were less important. In the long run, copper explained almost 30% of the IGBVL variation.

These local studies connect with the global literature, which also points out that macroeconomic fundamentals matter a lot for financial markets. For instance, Valadkhani, Chancharat, and Havie (2009) analyzed how commodity prices affect capital markets and concluded that factors such as inflation, interest rates, and external demand must be included when studying stock market behavior, especially in economies based on commodities.

In other countries, the relation between macroeconomic variables and stock markets has also been studied in detail. For example, Nordin and Ismail (2014) examined Malaysia and found that palm oil prices had a clear effect on the stock market. They also showed cointegration among interest rates, exchange rates, and

the stock index, which proves why cointegration methods are useful when trying to study long-term relations.

Later, Fahmi, Geetha, and Mohidin (2017) continued this type of research also in Malaysia. Using Johansen's cointegration test and a VECM model, they proved that oil prices, interest rates, inflation, and exchange rates have a stable long-run relationship with stock returns. Their work supports the idea that VECM is a good tool to explain how economic and financial variables move together over time.

Other studies in North Africa, like Barakat, Elgazzar, and Hanafy (2015), found causal links between stock indices and macroeconomic factors in Egypt and Tunisia. With VAR models and Granger causality tests, they showed that stock market returns in those emerging economies are influenced by many macroeconomic factors, which may vary with both external and internal conditions.

Research in developed markets also brings useful evidence. Hellberg (2021), for example, studied the Swedish stock index (OMXS30) and tested how U.S. macroeconomic variables affect it. Using the Dividend Discount Model (DDM) and OLS regression, he found that the money supply and the federal funds rate had strong effects on stock performance. This demonstrates how fundamentals influence valuations by changing discount rates and expected profits.

Several other works focus on oil prices. Chiou and Lee (2009) showed, using the ARJI model, that unexpected oil price increases had stronger and asymmetric effects on the S&P 500. Sharma, Ankit, and Sasmita (2018) studied India and found that crude oil influenced sector indices in the short run, even if no long-run relationship was found. Earlier, Sadorsky (1999) had already demonstrated that oil price volatility had a big impact on U.S. stock returns, especially during fast price increases. These results show why it is necessary to consider time effects when analyzing oil prices.

In Malaysia, Bekhet and Mugableh (2012) also confirmed long-term links between stock indices and macroeconomic variables such as GDP and inflation. Their results made it clear that fundamentals must be included when explaining stock market behavior. Again, Nordin and Ismail (2014) highlighted that commodity prices are central in economies based on natural resources. These comparisons are very useful for the Peruvian case.

Even though there are many studies worldwide, the Peruvian case is still less developed. Few studies apply cointegration models or structural break analysis using

domestic variables. The international evidence already shows how important these fundamentals are, but Peru's specific conditions are not fully studied yet. This research tries to reduce that gap by using a VECM to evaluate long-term and short-term dynamics between the chosen variables. In this way, the study adds a contribution that fits the Peruvian context and helps to understand financial markets in emerging economies.

2. Theoretical Framework

The stock index is often seen as a reference to know how the market is doing in general. Because of that, this section tries to explain some theories that are usually used in finance and can help to understand how the BVL connects with different macroeconomic variables. The theoretical framework works like a base or foundation for the study, since it shows how markets can react to economic changes and how investors usually behave. Two theories are mainly reviewed here: the Efficient Market Hypothesis (EMH) and the Arbitrage Pricing Theory (APT).

2.1 Efficient Market Hypothesis (EMH)

This hypothesis was introduced by Fama in 1970. The central idea of this theory is quite simple: financial markets are very quick in reacting to new information, so the prices of assets, like stocks, already show almost everything that is known at that time. In practice, this means that it is very difficult for someone, whether an investor or a trader, to earn returns that are above the average for a long period, because the information is already inside the price when it becomes public. In other words, the market is always one step ahead.

Later, Fama (1991) divided this theory into three forms or levels. The first one is the weak form, which says that past data, such as prices and volume, are already reflected in the asset prices. The second one is called semi-strong, and it argues that not only past data but also all public information, like company results, news, or economic reports, are also included in the stock prices. The third one is the strong form, which goes even further by saying that even private or insider information is also considered in the market price, so the market would be perfectly efficient.

Although this theory became very important for finance and is often used in studies, it has also received many criticisms. For example, Grossman and Stiglitz (1980) explained that markets cannot be totally efficient, because in that case nobody would have the incentive to collect and analyze information. They suggested that some informed investors or very skilled traders can take advantage of these small inefficiencies and obtain extra returns, at least for some time. These criticisms gave space to other fields like behavioral finance, which focuses on how psychology affects investors, and also modern practices such as quantitative or algorithmic trading, which show that sometimes prices move not only for information but also for

strategies or human behavior.

2.2 Arbitrage Pricing Theory (APT)

The second theory included here is the APT[1]. This is an important model because it explains that stock returns are influenced not only by one single factor but by many macroeconomic factors that work together at the same time (Ross, 1976).

According to the CFA (1994), this theory has two main assumptions. The first assumption is that the variation between returns and expected returns can be separated into two parts. The first part shows how the asset is exposed to general economic factors, and this is usually measured with a coefficient or beta, while the second part is more specific to the company or asset itself, and it includes particular elements that can affect its performance. The second assumption says that it is not achievable to get arbitrage profits without risk, because competition in financial markets eliminates that possibility. This means that, in practice, no investor can earn money without facing risk.

The APT has been very useful because it connects macroeconomic fundamentals with the the stock market (Chen et al., 1986). It indicates that exchange rates, inflation, commodity prices, GDP, foreign investment, or even money supply, can directly influence company profits, stock prices, expected dividends, and future cash flows. When one or more of these variables change strongly, the systematic risk of the whole market increases, and this happens even if investors hold diversified portfolios (Chowdhury et al., 2006). For this reason, APT provides a theoretical justification for the selection of the variables in this research, and the model can be written in the following way:

$$R_{it} = rf_t + \beta_i X_t + e_t \quad (1)$$

$$R_{it} = rf_i + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + e_t \quad (2)$$

1 The APT is considered a complement to the Capital Asset Pricing Model (CAPM), as both focus on systematic risk. However, APT is distinguished by its flexibility in incorporating multiple risk factors rather than relying on a single market portfolio assumption (Ross, 1976).

In this equation, R_{it} denotes the market returns during period t, representing the dependent variable in the model. The term rf_t refers to the risk-free rate at time t[2]. (X_t) comprises predetermined economic factors influencing stock returns, where X_1, X_2, X_3, X_4 correspond to specific macroeconomic variables that will be presented in equation 3. The coefficients $(\beta_1, \beta_2, \beta_3, \beta_4)$ capture the sensitivity of returns to change in these macroeconomic factors. Finally, e_t represents the error term at time t.

[2] The risk-free rate (rf_t) typically refers to the yield of a government security with a maturity that matches the investment horizon, such as short-term Treasury bills. Its inclusion in the model accounts for the baseline return an investor would expect without assuming additional risk.

3. Hypothesis

The theoretical model that supports this study allows formulating a set of hypotheses about how the main variables interact with the Peruvian stock market (BVL). It is expected that both GDP and copper prices (CP) will maintain a positive relationship with the BVL. The reasoning is that when GDP grows and copper prices rise, the level of economic activity increases, and this tends to translate into higher revenues for companies, especially in the mining sector, which is fundamental for Peru.

In contrast, policy rates, which are determined by the Central Bank of Peru, are anticipated to affect the BVL negatively. Higher rates usually increase financing costs and reduce the incentives to invest, which ends up lowering business profits and discouraging stock market activity. The case of the PEN/USD exchange rate is more ambiguous, since its relationship with the BVL may vary depending on the context. In some circumstances, depreciation can favor exporters, but in others, it can discourage investment flows.

Table 1 presents the expected long-term results in a summarized way:

Table 1
Expected Outcomes

Variables	Expected result
CP	+
GDP	+
Interest Rate	-
PEN/USD	+ -

Source: author's own work

Beyond the long-run perspective, the study also considers short-run dynamics, the stability of relationships, and possible structural breaks. In this sense, the following points are proposed:

- Short-Term Dynamics:
    - A rise in copper prices is expected to cause an immediate increase in the BVL, given the relevance of mining revenues.

    - GDP growth should also positively influence the BVL by reflecting greater confidence and more intense economic activity.
    - Higher interest rates would likely weigh negatively on the BVL due to higher costs of credit and the pressure on profits.
    - The exchange rate (PEN/USD) may have mixed effects depending on whether it boosts exports or discourages foreign investment.
- Stability:
    - The relationship between macroeconomic variables and the BVL is expected to remain generally stable, even if external shocks cause temporary imbalances.
- Structural Breaks:
    - Breakpoints are expected to coincide with the global financial crisis. Although these events could temporarily disrupt relationships, they are not expected to alter the long-run balance.

These hypotheses provide the basis for the empirical analysis. By combining long-term relationships with short-term dynamics, together with stability and break tests, the study seeks to shed light on how macroeconomic variables influence the Peruvian stock market. The contribution is not only academic, but also useful for investors, companies, and policymakers who must make decisions in a changing environment.

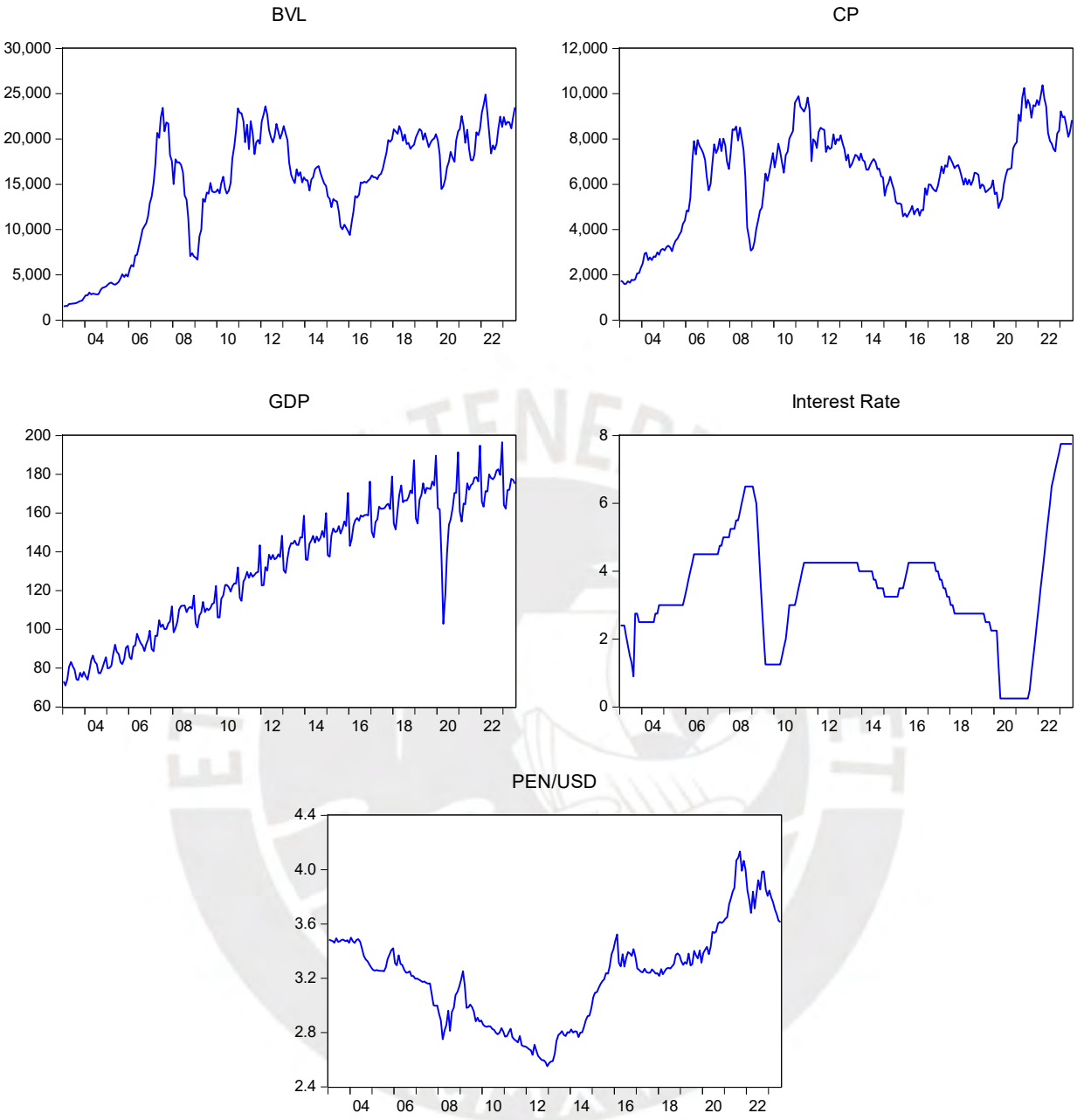
4. Descriptive Statistics

Figure 1 shows the behavior of the main economic variables between January 2003 and July 2023. In that period, the BVL suffered three notable declines: 2006–2008, 2010–2016, and 2020. The drops in 2008 and 2020 were related to the international financial crisis and the pandemic, which destabilized markets and generated sell-offs. The decline observed between 2010 and 2016 had different causes: excess supply in commodity markets, slower growth in China (a key buyer of copper), and uncertainty in the global economy. All of this reflects how dependent the BVL is on international conditions and especially on the performance of commodities.

GDP also recorded strong shocks. The most serious was in 2020, when it contracted by 11.1% because of the pandemic and the restrictions on activity. The following year, the economy recovered strongly, supported by the reopening of production and consumption. Interest rates, for their part, also showed marked changes in times of crisis. In 2008, the central bank reduced them to encourage recovery after the global financial collapse, and in 2020 it lowered them again to historic levels to limit the impact of the pandemic. These movements show the active role of monetary policy in cushioning crises.

The PEN/USD exchange rate also responded to uncertainty. During periods of instability, such as in 2008 and 2020, the sol depreciated as demand for the dollar increased as a refuge asset.

Figure 1
Multiple Line Graphs



Source: Bloomberg and BCRP data

The descriptive summary indicates that the BVL averaged 15,033.15 points, with high volatility (standard deviation of 6,341.30) and a wide range from 1,517.40 to 24,915.50. Interest rates were more stable, averaging 3.53% and fluctuating between 0.25% and 7.75% (standard deviation 1.65). GDP showed sustained growth with an average of 132.83 billion, although with interruptions that generated a deviation of 33.46 billion. The exchange rate averaged 3.216, with a range between 2.552 and 4.135. Copper prices were the most unstable, with an average of 6,387.41

and extreme values from 1,590.50 to 10,375.00. These numbers confirm how exposed Peru is to external shocks. Descriptive Statistics are displayed in Table 2 below:

Table 2
Main Statistics during the period 2003-2023

	BVL	Interest Rate	GDP	PENUSD	CP
Mean	15033.150	3.528	132.827	3.216	6,387.411
Median	16132.870	3.500	137.651	3.254	6695.000
Maximum	24915.500	7.750	196.491	4.135	10375.000
Minimum	1517.400	0.250	71.079	2.552	1590.500
Std. Dev.	6,341.295	1.650	33.459	0.357	2,068.996
Skewness	-0.773	0.199	-0.207	0.213	-0.492
Kurtosis	2.454	3.416	1.802	2.555	2.667
Jarque Bera	27.634	3.412	16.542	3.915	11.113
Probability	0.000001	0.1815	0.0002	0.1412	0.0038
Sum	3713189	871.3	32808.25	794.23	1577691
Sum Sq. Dev.	9.89E+09	670	275405.8	31	1.05E+09
Observations	247	247	247	247	247

Source: Author's own elaboration

The correlation matrix adds more detail. The BVL showed a weak negative relationship with the PEN/USD (–0.103), suggesting that a depreciation of the sol usually coincides with slight declines in the stock market. On the other hand, copper prices displayed a strong positive correlation (0.855), and GDP a moderately high correlation (0.724), both reinforcing their influence on the BVL. Interest rates had only a weak positive relationship (0.149), which indicates that their impact is limited compared to other variables.

It should be emphasized that extreme episodes, such as the pandemic in 2020, could distort correlations. Outliers of this type can exaggerate or reduce the strength of relationships, so careful handling of the data is essential. Tables 2 and 3 present the descriptive results and the correlation matrix in detail.

Table 3
Pearson's Correlation Matrix from 2003-2023

	BVL	Interest Rate	GDP	PENUSD	CP
BVL	1.000	0.149	0.724	-0.103	0.855
Interest Rate	0.149	1.000	0.047	-0.145	0.182
GDP	0.724	0.047	1.000	0.277	0.529
PENUSD	-0.103	-0.145	0.277	1.000	-0.119
CP	0.855	0.182	0.529	-0.119	1.000

Source: Author's own elaboration

5. Methodology

5.1 Data

In this study, the focus is on the analysis of Peruvian stock market index (BVL) and four main economic variables: the monetary policy rate (Interest Rate), copper prices (CP), the nominal exchange rate (PEN/USD), and gross domestic product (GDP). The dataset is monthly and includes 247 observations, covering the period from January 2003 to July 2023. The information was taken from two main sources: the Bloomberg Terminal and the official statistics published by the Central Reserve Bank of Peru.

5.1.1 Chosen Variables

The chosen variables are based on what many other studies have done before and because these reflect the main features of the Peruvian economy. For this reason, the work includes GDP, the local policy interest rate, the PEN/USD, and copper prices. These variables are not only important in theory but also very connected with the real situation of the Peruvian economy.

Some authors, such as Rey (2013) and Miranda-Agripino and Rey (2022), say that international financial conditions can also influence emerging countries, for example with indicators like the VIX or the interest rate of the U.S. Federal Reserve. In this study, those international factors are not used. There are two reasons for that. First, even if they affect capital flows, their direct impact on the Peruvian stock market is usually small. Lahura and Vega (2014) explain that local factors usually explain the Peruvian capital market better, while global ones have only a secondary role. Second, adding those global indicators would make the model more complex but not necessarily more useful. Because of that, this research focuses only on domestic variables that show more clearly the internal link between the economy of Peru and its stock exchange.

5.1.2 Peruvian Stock Market Index (BVL)

The BVL is a composite index that includes 25 of the most traded and most relevant companies in the Lima Stock Exchange. In this study, the BVL is used as the dependent variable because it reflects the overall behavior of the Peruvian stock market. The companies that form the index are chosen according to factors such as

how often they are traded, the size of the transactions, and the number of operations, following the rules of the Central Reserve Bank of Peru (BCRP, 2023).

This index usually reacts a lot to movements in macroeconomic conditions, which makes it a good and practical measure to study. The BVL not only shows stock price movements but also includes the gains and losses from dividends and capital adjustments. Thanks to this, it gives a broader picture of the market. For that reason, it is often used by investors, companies, and also by policymakers to understand economic trends and to guide decisions (BCRP, 2023).

5.1.3 Gross Domestic Product (GDP)

The first economic factor is the Peruvian GDP, which measures the total production in a country, and it is one of the most common ways to see economic activity (Wesselink et al., 2007). It is very relevant for this research because changes in GDP usually influence investor confidence and also company profits, which are directly related to the stock market (Hellberg, 2021). Chen et al. (1986) also showed that during economic growth, firms expect higher future cash flows.

To make the analysis more precise, this study uses seasonally adjusted GDP (GDP_SA). This adjustment is necessary because it removes the seasonal effects that appear every year and lets the long-term trend be clearer. In this way, it is easier to see how the economic activity connects with the performance of the market across time.

5.1.4 Monetary Policy Rate (Interest Rate)

The second independent variable is the monetary policy rate defined by the Central Bank of Peru. This rate is one of the main tools of monetary policy because it decides how expensive borrowing is, how much liquidity is in the economy, and how investment choices are made. It also works as a benchmark for interbank loans and is controlled with mechanisms like open market operations or deposit and credit access (BCRP, 2023).

For the stock market, this rate is important because it shows how monetary policy affects financial activity. Most studies find that the relationship is negative: when the interest rate goes up, credit is more costly, firms reduce investment, and the stock market slows down (Farfán, 2020). Because of this, following the policy rate is a way to understand how central bank decisions affect the Lima Stock Exchange.

5.1.5 Nominal Exchange Rate (PEN/USD)

The third variable is the PEN/USD. In an open economy like Peru, the PEN/USD is important because it influences how competitive exports are and also the direction of capital flows. The Central Bank of Peru (2023) explains that changes in the nominal PEN/USD affect the income of exporting and importing companies, which later influences their stock prices. Movements in the exchange rate also affect investor confidence, company profits, and finally, the behavior of the BVL. Evidence from other emerging countries shows that when the local currency appreciates, the stock market tends to lose strength, especially in countries where exports are key to the economy (Barakat, Elgazzar, & Hanafy, 2015). Because of that, the exchange rate is one of the main drivers for understanding the Peruvian stock market.

5.1.6 Commodity Prices: Copper (CP)

CP were included as another variable because of their big role in the Peruvian economy. Mining has been important for the country for a very long time, and today Peru is still one of the top producers of copper worldwide. The U.S. Geological Survey shows that Peru has around 9% of global copper reserves, which makes it very important both in the international market and for the country itself (BCRP, 2018).

Even though copper prices are decided in international markets, they are very relevant for Peru. When copper prices change, they affect growth, public income, and foreign reserves. The Lima Stock Exchange also reflects this, since mining companies represent a big share of its capitalization and transactions.

What makes copper special is how fast and directly it affects the Peruvian market. Other global indicators, like the VIX or the U.S. Federal Reserve interest rate, influence Peru in a slower or more indirect way. On the other hand, copper price changes are quickly transmitted to the economy and the stock market. Martínez Rivera (2018) mentions that the BVL depends a lot on copper prices because the mining sector is still so important for Peru. For this reason, copper in this study is treated almost like a domestic factor, even though it is an international commodity.

5.2 Economic Model

Here, we explain how each variable is defined in the general model.

$$Y_t = f\left(BVL, Interest\ Rate, PEN/USD, CP, GDP_SA\right)$$

$$BVL = \beta_0 + \beta_1 Interest\ Rate_t + \beta_2\ PEN/USD_t + \beta_3 CP_t + \beta_4 GDP_SA_t + \varepsilon_t \qquad (3)$$

Where:

- GDP_SA_t: Seasonally adjusted GDP in period t
- ε_t: Error at time t

5.3 Econometric Model: VECM

In this research, we used a VECM to understand how some main variables move together with the market over time. The VECM comes from the Error Correction Model, but it's a bit more complete because it lets you see both the long-term relationship and what happens when there's a sudden change in one of the variables. So basically, it helps to know if things like copper prices, interest rates, the PEN/USD, and GDP keep a stable connection with the BVL, and how fast they go back to balance after something unexpected.

Before running the model, we had to make sure the data was stationary and cointegrated, because otherwise the VECM wouldn't work well. In this case, we used three lags, which helps to catch better reactions. That way, it's possible to see how each variable influences the market in a different way.

$$\Delta Y_t = \Phi D_t + \alpha\beta' Y_{t-1} + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \Gamma_3 \Delta Y_{t-3} + \varepsilon_t \qquad (4)$$

In this model:

- ΔY_t refers to the vector that includes the endogenous variables expressed in their first differences.
- ΦD_t indicates the deterministic components of the model.
- $\alpha\beta' Y_{t-1}$ shows the ECT. Here, α represents how fast the variables move back toward equilibrium, while β the vectors of cointegration.
- Γ_i includes the coefficients of the lagged differences, which reflect the short-run relationships
- ε_t is the vector of random errors.

As noted in Section 5.2, each variable in the model is defined as:

$$Y_t = [BVL, Interest\ Rate, PEN/USD, CP, GDP_SA]$$

The deterministic term Dt can be written as:

$$D_t = \mu_0 + \alpha p_0 \qquad (5)$$

Where:

- μ_0 stands for a not restricted constant, and
- αp_0 indicates a restricted constant.

The hypotheses of this study were formulated in line with its main objectives:

- $H_1 : \beta_1 > 0$ GDP (seasonally adjusted) shows a clear positive link with BVL's performance in the long run.
- $H_2 : \beta_2 > 0$ Copper prices also move in the same direction as the BVL, confirming that long-term connection.
- $H_3 : \beta_3 < 0$ Interest rates, on the other hand, tend to weigh negatively on the market's performance.
- $H_4 : \beta_4 \neq 0$ The PEN/USD exchange rate matters too, with effects that can swing either way depending on the context.

Within this framework, β represents the vector of cointegration that describes the equilibrium relationships among the variables over the long term.

5.4. Impulse – Response Functions (IRF)

Together with the VECM, IRF were used to better understand the short-term adjustments of the system. These functions trace the reaction of one variable when another one receives a shock, which makes them useful to complement the long-run analysis. For this research, the short-term horizon was defined as twenty-four periods, equivalent to about two years. This choice is justified because, within this window, the functions usually show convergence to a new balance, meaning that the initial disturbance is already absorbed and the economy moves towards its long-run path.

This two-year definition of the short run is common in financial econometrics, especially for emerging markets. Several studies support this view. For example, Lütkepohl (2005) explains that impulse responses normally stabilize within a few quarters or a couple of years, depending on the economic context. Similarly,

Edwards and Susmel (2001) show that Latin American markets typically adjust to external shocks in less than two years. With this evidence, the two-year horizon adopted here is consistent with both theory and empirical results.

5.5 CUSUM and Bai-Perron tests

To evaluate the stability and the possibility of structural breaks, the CUSUM and Bai-Perron tests were applied. These procedures are based on OLS[3] estimations and are not used to prove the cointegration relationships directly, but rather to detect whether the data were affected by sudden changes in the period under study. Identifying these breaks is important because events such as 2008 financial crisis or the COVID-19 outbreak may have temporarily altered short-run dynamics, even if the long-run equilibrium remained intact. In this sense, the tests provide complementary evidence that helps to interpret the results of the VECM in light of external shocks.

[3] Although OLS provides a baseline for examining variable relationships, it was not used to infer long-term connections due to potential biases in the coefficients caused by extraordinary shocks, such as the subprime crisis and the pandemic. Here, its sole purpose was to serve as a foundation for the CUSUM test, which assesses temporal stability in the estimated relationships.

6. Results

This part describes the estimation of VECM and its results. The steps were done in order. First, to stabilize the variance and to ensure comparability, variables were converted into logarithmic. Next, to verify whether the series were stationary unit root test were carried out. Afterwards, the right number of lags was determined using different information criteria. With this specification, the Johansen cointegration test was applied to identify possible long-run relationships. Based on these findings, the right model was decided, a VECM. Finally, some other tests were applied.

6.1 Unit Root Test (UR)

UR indicates that the variables are not stationary, since the p-values are higher than 0.05 . Yet, after applying first differences, the series turns stationary. This is clear because the p-values are 0, refusing the null hypothesis at 1% significance. This confirms that LBVL, LGDP_SA, LCP, LPENUSD, and the Interest Rate are integrated of order one, I(1). This means they have a unit root but turn stationary once their first difference is taken[4].

6.2 Optimal Lag Length

This test identifies three lags as the optimal specification according to the Akaike Information Criterion (AIC). AIC is commonly used in VECM estimations and works well with small samples. That is why three lags were chosen, because it captures both the long-term relations and the short-run adjustments in an efficient way[5].

6.3 Johansen Cointegration Test (JC)

JC confirms that there is at least one cointegration and supports the use of VECM framework. Specifically, both the test of Trace and Eigen reject the null hypothesis at 5%, confirming again that the variables are cointegrated[6].

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[4] The summary and the full set of unit root outcomes are shown in Appendices 1 and 2, respectively.

[5] The optimal lag length is presented in Appendix 3.

[6] Details of the test of Trace and Eigenvalue are displayed in Appendix 4 and Appendix 5, respectively.

6.4 Normalized Cointegration (NC)

At the same time, the NC equation gives a first view of the long-term relation before running the full VECM. The results show that CP, PEN/USD, and GDP_SA move as the BVL. Conversely, the Interest Rate displays a negative relationship with the BVL[7].

6.5 VECM

6.5.1 Long-Term Outcomes

The VECM estimation provides important information about the long-run dynamics. The equation of cointegration shows the following key results:

- Over the long run, interest rates show a significant negative link with the BVL. The t-statistic is |3.61489|, which is above 2, so it confirms significance at 5%. This suggests that when the policy rate rises, the BVL goes down over time.
- LCP and GDP_SA show a positive and significant relationship with the BVL. Their t-statistics are |8.95229| and |2.39023|, both higher than 2, which confirms significance at 5%. This means that higher copper prices and higher GDP are linked with a higher BVL in the long term.
- LPENUSD and the BVL do not exhibit a significant relationship. Its t-statistic is |0.82718|, which is lower than 2, so the effect is not significant. This indicates that PEN/USD does not impact the BVL over time.

ECT shows the speed of adjustment of the variables toward balance after a short-run deviation:

- For the BVL, the ECT is not significant (t-statistic = 0.62431, less than 2), so the BVL does not adjust much to equilibrium each period after a shock.
- For LCP, GDP_SA, and LPENUSD, the ECTs are also not significant (t-statistics = 0.50269, 0.51272, and 2.32210). This means these variables do not show strong short-term adjustments.
- For the Interest Rate, the ECT is also significant (t-statistic = 4.60587, greater than 2). This means that about 25.86% of the disequilibrium is corrected each period. In other words, the interest rate helps to restore equilibrium faster than the other variables.

[7] The NC coefficients are shown in Appendix 6.

The main VECM outcomes are displayed in Table 4:

Table 4
VECM Estimates

Cointegrating Eq	CointEq1				
LBVL(-1)	1.000000				
LCP(-1)	-1.471625				
	(0.16439)				
	[-8.95229]				
LGDP_SA(-1)	-0.57528				
	(0.24068)				
	[-2.39023]				
LPENUSD(-1)	-0.391358				
	(0.47312)				
	[-0.82718]				
INTEREST_RATE(-1)	0.107417				
	(0.02972)				
	[3.61489]				
C	6.204995				
Error Correction	D(LBVL)	D(LCP)	D(LGDP)	D(LPENUSD)	D(INTEREST_RATE)
CointEq1	-0.012425	0.009523	-0.003608	-0.009936	-0.258601
	(0.0199)	(0.01894)	(0.00704)	(0.00428)	(0.05615)
	[-0.62431]	[0.50269]	[-0.51272]	[-2.32210]	[-4.60587]

Source: Author's own elaboration

6.5.2 Impulse-Response Functions (IRF)

In this part, IRF analysis was also carried out to complement the long-term results and see how the variables move in shorter periods. Through the IRF, we can see how a shock in one variable spreads to the rest in the short run. Below, the main interpretations of the IRF are explained and compared with the long-term findings:

6.5.2.1 GDP Impact on the BVL (LGDP_SA ➔ LBVL)

The IRF for GDP (LGDP_SA) shows that a positive shock in GDP makes the BVL (LBVL) go up at the beginning, and the effect reaches its peak shortly after the shock. This positive response means that when Peru's economy grows, investors feel more confident, and the stock market activity increases. In the long run, GDP still keeps a positive and stable relation with the BVL, although the first reaction is stronger and then stabilizes as the economy reaches a new balance.

6.5.2.2 Exchange Rate Impact on the BVL (LPENUSD ➔ LBVL)

A positive shock in the PEN/USD (meaning an appreciation of the sol against the USD) first makes the BVL react negatively. This could be because exports become less competitive, which reduces investor sentiment. Around period 10 the negative effect starts to stabilize, and by two years the market goes back to equilibrium. Even if this reaction makes sense in economic theory, the long-term results do not show a significant relation between the PEN/USD and the BVL, which means the effect is mainly short-lived.

6.5.2.3 Interest Rate Impact on the BVL (INTEREST_RATE ➔ LBVL)

The IRF shows that when interest rates go up unexpectedly, the BVL goes down a little in the short term. This is expected, since higher interest rates increase financing costs and reduce company profits. In the long run, the negative effect of higher policy rates on the BVL is more relevant, but in the short run the correction is not very strong, showing that the market reacts step by step to changes in rates.

6.5.2.4 Copper Price Impact on the BVL Performance (LCP ➔ LBVL)

Since Peru exports a lot of copper, a positive shock in copper prices (LCP) creates an immediate and strong positive effect on the BVL. This happens because investors expect higher export revenues, which is good for the economy. The effect grows at first but starts to stabilize around period 13 and then converges to a neutral position by the end of two years. The short-term reaction is very quick and clear, and this is consistent with the long-term results, which also show that copper has a strong and lasting impact on the Peruvian stock market.

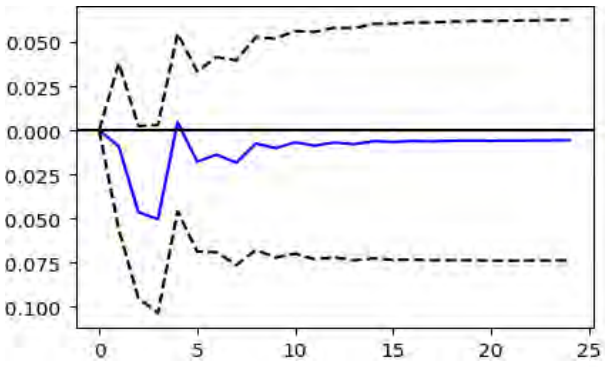
6.5.2.5 BVL Self-Response (LBVL ➔ LBVL)

The last panel shows how the BVL reacts to its own shocks. The result is that a disturbance in the BVL itself produces a strong effect at the beginning, but then this effect slowly goes down and stabilizes in the short term. This means that the Peruvian stock market can adjust quickly to internal shocks, and the fluctuations do not last too long. The market tends to go back to balance within two years, which is in line with the long-term findings.

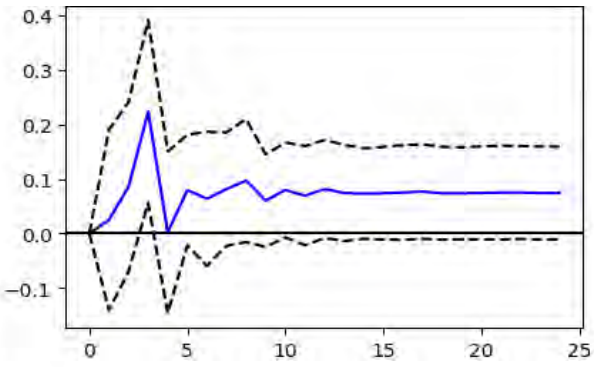
In summary, the IRF analysis shows that the macroeconomic variables studied have important but temporary effects on the BVL in the short run (around two years). During this time, the market adjusts to shocks and moves back to equilibrium. These short-term effects support the long-term results explained before, confirming that key macroeconomic variables have an important role in the Peruvian stock market.

Figure 2 shows the IRF results for 24 periods, and appendix 7 gives an extended analysis for both 24 and 247 periods.

Figure 2
IRF for LBVL - 24 Periods

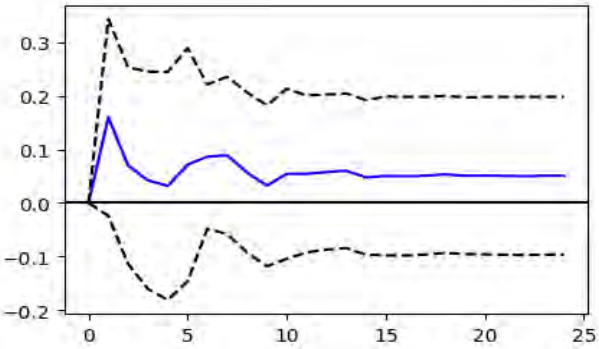


Interest_Rate → LBVL

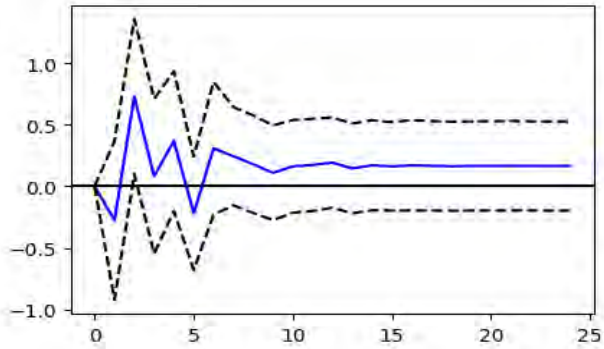


LCP → LBVL

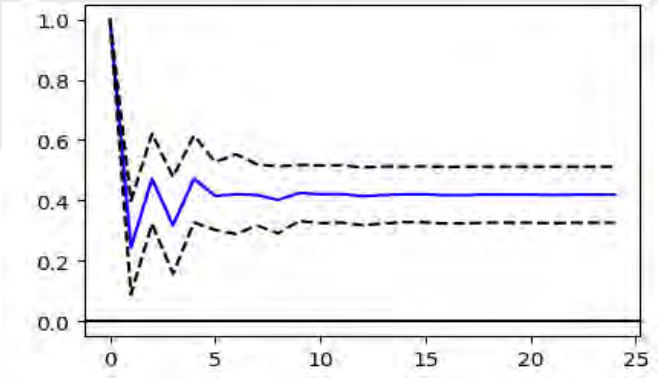
LGDP_SA → LBVL



LPENUSD → LBVL



LBVL → LBVL



Source: Author's own elaboration

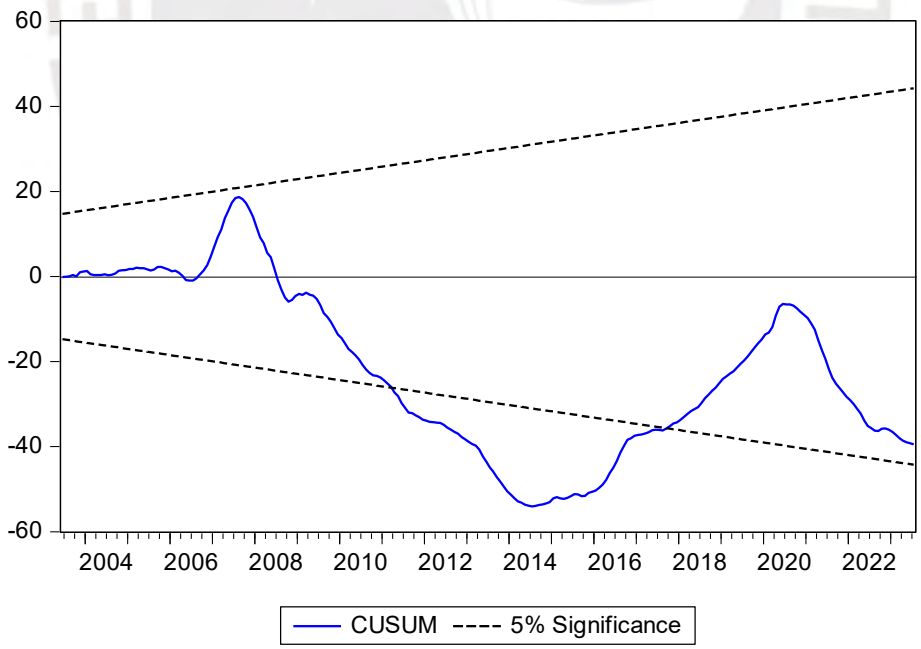
6.5.3 Stability and Structural Break Analysis

This section has two purposes: to see if the data is generally stable during the study period, and to check nningstructural changes in the relation between the macroeconomic variables and the BVL. Since the period analyzed is 2003–2023, it includes big events like the subprime crisis and the pandemic, so looking for breaks is very important. For this, two main tests were used: CUSUM and Bai-Perron. These tests do not analyze long-term cointegration like the VECM, but they help to detect possible structural breaks that affect the short-term dynamics.

6.5.3.1 CUSUM Test

The CUSUM test at 5% significance level shows that the time series had important structural breaks in 2008, 2014, and 2020. These dates match with global economic events and crises. Apart from these moments, there were no other relevant structural changes, so the relations between the variables stayed generally stable, except for the shocks caused by those events.

Figure 3
CUSUM Test



Source: Author's own elaboration

6.5.3.2 Bai-Perron Test (BP)

BP was also used to detect breakpoints in time. This test is good because it can identify several breaks without needing to define the dates before. The results

found four breakpoints: 2006, 2010, 2016, and 2020. These moments also match with important economic situations:

- December 2006: This period preceded the 2008 financial crisis and involved shifts in market expectations.
- September 2010: linked with the recovery after the crisis, when markets were still adjusting.
- April 2016: connected with the strong fall in commodity prices, especially copper, which is very important for Peru's mining economy.
- February 2020: the beginning of the COVID-19 pandemic, which created high global volatility.

Table 5
Bai-Perron Test

Sequential F-statistic determined breaks:			4
Break Test	F-statistic	Scaled F-statistic	Critical Value**
0 vs. 1 *	38.8504800	194.252400	18.23
1 vs. 2 *	42.0774400	210.387200	19.91
2 vs. 3 *	18.5676900	92.838440	20.99
3 vs. 4 *	13.4136000	67.068000	21.71
4 vs. 5	0.0000000	0.000000	22.37

* Significant at the 0.05 level.
** Bai-Perron (Econometric Journal, 2003) critical values.

Break dates:

	Sequential	Repartition
1	2006M12	2006M12
2	2016M04	2010M09
3	2010M09	2016M04
4	2020M02	2020M02

Source: Author's own elaboration

These breakpoints show that external shocks influenced the variables temporarily, but the long-term relations stayed strong. The Bai-Perron test gives more background to understand the results, but it does not mean that the VECM lost its stability. So, the model can still explain the main macroeconomic relations, even if there were short disruptions.

In summary, both the CUSUM and Bai-Perron tests confirm that there were important structural breaks during the study period, linked to events like the 2008 crisis, the copper price fall between 2010–2016, and the COVID-19 pandemic. It is crucial to highlight that these tests are based on OLS and are only benchmarks to detect breaks, not to evaluate the long-term relations measured by the VECM. Overall, the results show that the VECM is robust and can still capture the persistent macroeconomic dynamics, even when there are external shocks that affect the short-term.

Conclusion

This study aims to explore how the Peruvian stock market (BVL) is related in the long run to key domestic macroeconomic factors such as copper prices, GDP, the PEN/USD, and policy rates. By applying a VECM, it was possible to see that there are important relations that go beyond short-term market fluctuations.

Why is this important? For investors, knowing these long-term links can help to take better decisions, not only when choosing assets but also when thinking about risk management when the economy changes. For companies listed in the BVL, especially those in sectors like mining that are very sensitive to external shocks, it means they can plan better their hedging strategy if they understand how these macro variables affect their share performance. And for policymakers like the Central Bank or the Ministry of Finance, the findings can serve as input to design measures that keep the economy and the capital market in more stable conditions.

The results suggest that, over the long term, copper prices move in the same direction as the BVL. This finding confirms how much Peru's stock market is tied to the mining sector and to international commodity cycles. When copper prices move, the effect is seen not only in export revenues but also in the stock market. For investors, this means they must follow global commodity prices very carefully, since it can help to protect portfolios or find opportunities. For mining companies, it shows the need to adjust operations and financial planning to these cycles. From a policy point of view, this high exposure to commodities is a reminder that Peru needs to continue with diversification of the economy.

The analysis also found a positive long-term relation between seasonally adjusted GDP (GDP_SA) and the BVL. This shows the strong link between economic activity and stock market behavior. When the economy grows, the stock market usually follows because company earnings improve and investor confidence grows. For investors, GDP growth can be seen as a useful signal to invest or anticipate market trends. For firms, it is a sign that they must align their activity with economic cycles. And for policymakers, it reminds them of the importance of maintaining sustainable growth, not only for development but also to give more vitality to the capital market.

The study also confirmed that policy rates have a significant and negative long-term effect on the BVL. This is consistent with theory. Higher policy rates mean

more expensive credit, which reduces investment and consumer spending, both necessary to support stock prices. For central banks, this represents a delicate challenge: they must control inflation but at the same time avoid stopping investment. Both investors and firms need to follow interest rate movements, because they have a direct influence on portfolios, valuations, and performance.

The PEN/USD did not show a statistically significant long-run relation with the BVL. This could mean that the influence is indirect or more complex, maybe because exporting firms hedge their currency risk or because Peru's currency regime has been relatively stable. Whatever the case, the exchange rate should be analyzed in a broader context and not alone when evaluating stock market effects.

The Error Correction Term (ECT) gave some additional information. While BVL, copper prices, GDP_SA, and PEN/USD did not show significant correction dynamics, interest rate did. Its ECT was significant, with an adjustment rate of 25.86 percent. This means that interest rates have a tendency to correct disequilibria faster, acting as a stabilizer compared to the other variables.

The Impulse Response Function (IRF) added short-term evidence. In the short run, positive shocks in GDP and copper prices gave immediate improvements in the stock market, probably due to investor confidence and the importance of mining for the economy. On the other hand, an appreciation of the sol against the US dollar produced a short fall in the BVL, and interest rate hikes generated a slower decline. These short effects are temporary but consistent with the long-term relations observed in the model. This confirms the importance of looking at both immediate and long-term responses to understand the behavior of the Peruvian capital market.

Structural break tests (CUSUM and Bai-Perron) were also applied. These are not part of the VECM framework but help as complementary checks. The results showed that even with strong shocks like the 2008 global crisis, the copper price fall between 2010 and 2016, and the COVID-19 pandemic, the long-term relations between the BVL and the macro variables stayed quite stable. Only temporary changes were seen. This supports the robustness of the model and shows that Peru's market, although vulnerable, has some structural resilience.

What makes this study different is the use of a twenty-year sample, a model not applied before in Peru for this topic, and its practical implications. Most previous studies used shorter periods like five or ten years, but this one covers two decades, including many external shocks. This gives stronger evidence for a long-term model.

While many studies in Peru use VAR, OLS, or ARDL, this research applies VECM, which can capture both long-term relations and the speed of adjustment. In addition, IRF was used for short-term analysis and structural break tests for robustness.

Looking more closely at the results, some key points can be made. The strong positive relation between CP and the BVL shows the structural dependence of Peru on mining exports. This is positive when prices go up, but dangerous when they fall, so diversification is necessary. The positive relation between GDP_SA and the BVL shows how much the market depends on economic growth. The negative relation with policy rates confirms the importance of monetary policy. The minor effect of the PEN/USD suggests that currency does not have a direct role in the market over the long term, maybe because of hedging or stability.

Like any research, this study has limitations. It uses past data from 2003 to 2023, which may not capture future changes. It only considers four macroeconomic variables, leaving out factors like politics, inflation, or technology. The VECM assumes linear relations, which may not reflect complex dynamics. And the data quality in emerging markets is not always perfect, which can affect results.

In summary, this study explains how economic conditions and the Peruvian stock market performance interact over time. The findings are useful for investors, firms, and policymakers when making decisions. Future works can include more variables (like the VIX or Fed funds rate), apply non-linear models, or focus on new sectors in the Peruvian economy. This would help to deepen the understanding of the financial market and its relationship with the economy.

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Appendix

Appendix 1: Unit Root Test Summary

Table 6
Unit Root Test Summary

Variables	Level	1st difference
LBVL	0.1393	0.0000
LGDP_SA	0.8758	0.0000
LCP	0.0562	0.0000
LPENUSD	0.7586	0.0000
Interest Rate	0.7733	0.0000

Source: Author's own elaboration

Appendix 2: Full Unit Root Test

Table 7
Unit Root on the variables

Unit Root on LBVL

			t-Statistic	Prob.*
Augmented Dickey-Fuller		test statistic	-2.982376	0.139300
Test critical values:	1% level		-3.996113	
	5% level		-3.428349	
	10% level		-3.137574	

*MacKinnon (1996) one-sided p-values

Unit Root on D(LBVL)

			t-Statistic	Prob.*
Augmented Dickey-Fuller		test statistic	-8.077876	0.000000
Test critical values:	1% level		-3.996113	
	5% level		-3.428349	
	10% level		-3.137574	

*MacKinnon (1996) one-sided p-values

Unit Root on LCP

			t-Statistic	Prob.*
Augmented Dickey-Fuller		test statistic	-3.381545	0.056200
Test critical values:	1% level		-3.996113	
	5% level		-3.428349	
	10% level		-3.137574	

*MacKinnon (1996) one-sided p-values

Unit Root on D(LCP)

			t-Statistic	Prob.*
Augmented Dickey-Fuller		test statistic	-8.618829	0.000000
Test critical values:	1% level		-3.996113	
	5% level		-3.428349	
	10% level		-3.137574	

*MacKinnon (1996) one-sided p-values

Unit Root on LGDP_SA

			t-Statistic	Prob.*
Augmented Dickey-Fuller		test statistic	-2.470559	0.342600
Test critical values:	1% level		-3.996113	
	5% level		-3.428349	
	10% level		-3.137574	

*MacKinnon (1996) one-sided p-values

Unit Root on D(LGDP_SA)

			t-Statistic	Prob.*
Augmented Dickey-Fuller		test statistic	-14.86025	0.000000
Test critical values:	1% level		-3.996113	
	5% level		-3.428349	
	10% level		-3.137574	

*MacKinnon (1996) one-sided p-values

Unit Root on LPENUSD

			t-Statistic	Prob.*
Augmented Dickey-Fuller		test statistic	-1.677222	0.758600
Test critical values:	1% level		-3.9958	
	5% level		-3.428198	
	10% level		-3.13749	

*MacKinnon (1996) one-sided p-values

Unit Root on D(LPENUSD)

			t-Statistic	Prob.*
Augmented Dickey-Fuller		test statistic	-16.07236	0.000000
Test critical values:	1% level		-3.995956	
	5% level		-3.428273	
	10% level		-3.137529	

*MacKinnon (1996) one-sided p-values

Unit Root on LINTEREST_RATE

			t-Statistic	Prob.*
Augmented Dickey-Fuller		test statistic	-1.642484	0.773300
Test critical values:	1% level		-3.995956	
	5% level		-3.428273	
	10% level		-3.137529	

*MacKinnon (1996) one-sided p-values

Unit Root on D(LINTEREST_RATE)

			t-Statistic	Prob.*
Augmented Dickey-Fuller		test statistic	-8.52209	0.000000
Test critical values:	1% level		-3.995956	
	5% level		-3.428273	
	10% level		-3.137529	

*MacKinnon (1996) one-sided p-values

Source: Author's own elaboration

Appendix 3: Lag Selection

Table 8
VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-229.9936	NA	4.92E-06	1.966473	2.039203	1.995781
1	1805.456	3968.702	2.43E-13	-14.85738	-14.42100*	-14.68153
2	1858.634	101.46	1.92E-13	-15.09317	-14.29315	-14.77078
3	1908.973	93.93823	1.55e-13*	-15.30521*	-14.14154	-14.83629*
4	1933.463	44.67619*	1.56E-13	-15.30095	-13.77363	-14.68548
5	1949.782	29.08743	1.68E-13	-15.2283	-13.33734	-14.46629
6	1968.212	32.07944	1.78E-13	-15.17332	-12.91871	-14.26478
7	1989.677	36.46304	1.84E-13	-15.14374	-12.52548	-14.08865
8	2001.155	19.01793	2.08E-13	-15.03059	-12.04868	-13.82896

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
Source: Author's own elaboration

Appendix 4: Cointegration Test 1

Table 9
Trace Cointegration Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value 0.05	Prob.**
None *	0.131029	71.98578	69.81889	0.0332
At most 1	0.067161	37.85749	47.85613	0.3082
At most 2	0.042102	20.96354	29.79707	0.3599
At most 3	0.033321	10.51117	15.49471	0.2434
At most 4	0.009323	2.276178	3.841466	0.1314

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
*denotes rejection of the hypothesis at the 0.05 level
MacKinnon-Haug-Michelis (1999) p-values
Source: Author's own elaboration

Appendix 5: Cointegration Test 2

Table 10
EigenValue Cointegration Test

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.131029	34.12829	33.87687	0.0467
At most 1	0.067161	16.89396	27.58434	0.5891
At most 2	0.042102	10.45237	21.13162	0.7014
At most 3	0.033321	8.234989	14.2646	0.3553
At most 4	0.009323	2.276178	3.841466	0.1314

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

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

Source: Author's own elaboration

Appendix 6: Cointegration Test 3

Table 11
Normalized Cointegrating Coefficients

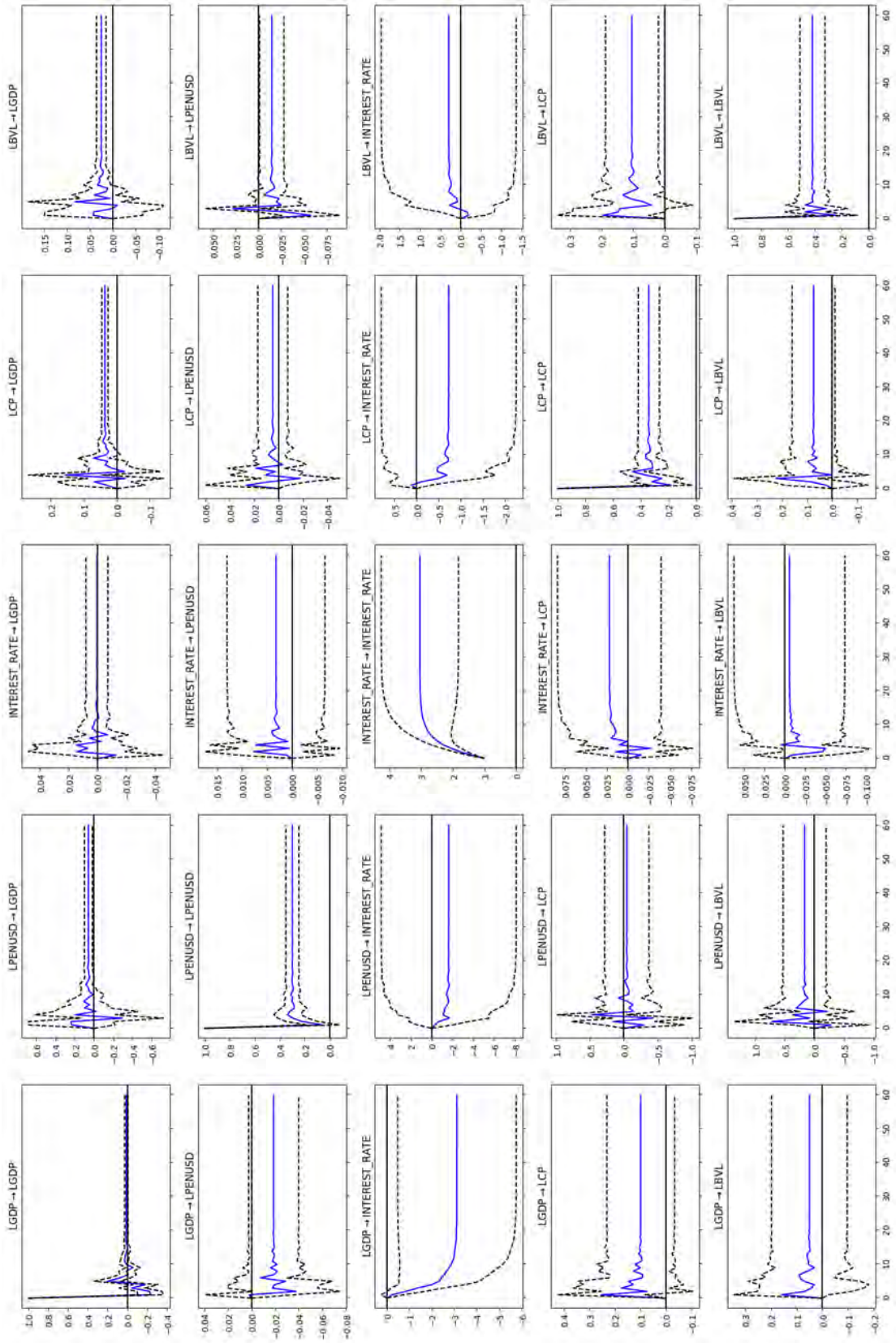
1 Cointegrating Equation(s):	Log likelihood	1765.164		
Normalized Cointegrating Coefficients (standard error in parentheses)				
LBVL	LCP	LGDP	LPENUSD	INTEREST_RATE
1.000000	-1.471625	-0.57528	-0.391358	0.107417
	(-0.16439)	(0.24068)	(0.47312)	(0.02972)

Adjustment Coefficients (standard error in parentheses)	
D(LBVL)	-0.012425
	(0.0199)
D(LCP)	0.009523
	(0.01894)
D(LGDP_SA)	-0.003608
	(0.00704)
D(LPENUSD)	-0.009936
	(0.00428)
D(INTEREST_RATE)	-0.258601
	(0.05615)

Source: Author's own elaboration

Appendix 7: Set of Impulse and Response Function (IRF)

Figure 4
Full Set of IRF Graphs for LBVL over 247 Periods



Source: Author's own elaboration