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Short-run and long-run effects of copper price on Junín's economic growth

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A B S T R A C T

Our research used a SVAR to analyze the underlying copper price shocks, that is, a commodity shock for the Junín department in Peru. The results of a short- and long-run SVAR were based on traditional matrix constraints that capture the fact that domestic shocks do not affect international prices. The main conclusion is that before the pandemic a shock in the international price of copper decreases economic growth and inflation in the department of Junín in Peru, after the pandemic the opposite happens. As a result of the model, the short and long-run effects of the international copper price on the main macroeconomic variables of Junín in Peru are statistically significant. Before the pandemic, the dynamics of the international copper price reflected the existence of the curse of mining resources in copper institutions. Before the pandemic, a percentage increase in the international price of copper decreased economic growth, reflecting the existence of the mining resource curse in copper institutions. After the pandemic, a percentage increase in the price of copper increases economic growth by up to 0.0488%, then decreases over time, noting the transitory effect of economic recovery and poor management of mineral resources.

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1. Introduction

Our present research measures the impact of a commodity shock such as the international price of copper on the main aggregate variables of the Junín department in Peru. For this purpose, we use a short-run and long-run Structural Vector Autoregressive (SVAR) model, based on traditional matrix constraints that capture the fact that domestic demand, supply and interest rate shocks do not affect international prices. We focus on the department of Junín because according to the Ministry of Foreign Trade and Tourism (2022), Junín is the fourth national copper producer (10%) after Ancash, Arequipa and Apurímac. The exportable supply of copper is 80% of the total, except for mineral production exported through other departments such as Lima. The copper industry is led by Chinalco Mining and Metco Trading, which are the main mineral extraction companies.

We compile data from the Central Reserve Bank of Peru (BCRP) and the Institute of Statistics and Informatics (INEI). The estimated sample size is 132 monthly observations corresponding to the period between January 2012 and December 2022. Within the study period, two subsamples are used, the first, before the pandemic, which runs from January 2012 to January of 2020; and the second, after the pandemic, which runs from February 2020 to December 2022. We use this configuration because after the COVID-19 pandemic the macroeconomic variables began to recover and grow, so, if only we analyze a very recent period, the results could be very optimistic.

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In general, there has been a positive correlation between the international price of minerals such as copper and economic growth. However, there is the theory of the resource curse or Dutch disease, which argues that countries with the greatest endowment of natural mineral or other resources are not those that obtain greater well-being. Therefore, not all departments within the country abundant in natural resources in the copper industry experienced rapid and sustained economic growth. As such, an ample endowment of mineral resources can be considered a curse for some departments in Peru. In this way, the resource curse theory contradicts a possible positive relationship between the price of copper and economic growth in the department of Junín.

Our main findings showed that, before the pandemic, a copper price shock negatively affects Gross Domestic Product (GDP) growth, inflation and nominal rate, thus fulfilling the natural resource curse. On the contrary, after the pandemic, the abundance of mining resources such as copper can have positive effects on economic growth. Thus, after the pandemic, a unit percentage increase in the international price of copper increases GDP growth by up to 0.0488%, but this result may be transitory if the Junín department does not generate institutions that apply public policies or efficient profitable investments. In the long-run, a copper price shock negatively affects GDP growth until the second period, then a recovery and subsequently a fall can be seen, so we confirm that the gains from this shock are transitory.

For better understanding, we maintain a sequential structure. Section 2 presents the literary review. Section 3 presents the general hypothesis and the specific hypotheses. Section 4 presents the SVAR methodology to follow. Section 5 shows the results and section 6 discusses and concludes.

2. Literary Review

In current literature, the price of copper has historically been a key variable in the global economy, particularly in countries where copper mining is a major industry. If we consider the copper market from 1880 to 2020, Stuermer (2022) found that a shock to global demand for commodities generates a 10% increase in the price of copper and a 5% increase in global copper production. Therefore, the price of copper is an important generator of business cycles, driving important political and social changes, from the nationalization of mines to the fall of governments. Thus, we analyze the literature of the resource curse theory or Dutch disease, which states that countries with many mineral resources are not necessarily those with the greatest well-being in terms of economic growth.

In this regard, Auty (2002) argued that natural resources can distort the economy to such an extent that the benefit becomes a curse. Considering Peru, the author highlighted that the curse of natural resources must be avoided because it drains the competitiveness of the agricultural and manufacturing sector, so in the long-run growth is not stable. Sachs and Warner (1995) found a negative relationship between the endowment of natural resources and economic growth. Sachs and Warner (2001) found that not all the countries richest in natural resources in the oil sector experienced rapid and sustained economic growth. Consequently, countries with many natural resources competed with higher prices in non-natural resource sectors, resulting in a loss of competitiveness. As such, countries with abundant natural resources do not achieve the expected economic growth. Stijns (2005) suggested that natural resource abundance has not been a significant structural determinant of economic growth in the 1970s and 1980s. For Brunnschweiler (2008) and Petermann et al. (2007), the abundance of natural resources (especially minerals) could result in corruption and rent-seeking behavior that damage the quality of government, which negatively affects economic performance. Alternatively, theories on the relationship between the international price of copper and economic growth have experienced significant development over time. Some authors found a positive relationship due to the commodity boom after 2010, some others found an opposite relationship because government institutions did not know how to generate long-term productive investments.

Páez (2017) found that a shock of one standard deviation in commodity prices impacts the real growth rate of Latin American countries by 0.22%. Drechsel and Tenreyro (2018) found that a shock in commodity prices explains 38% of the variance of Argentine GDP, 42% of the variance of consumption, and 61% of the variance of investment. Pedersen (2019) showed that an increase in the price of copper caused by higher international demand implies higher economic growth in Chile, while supply impacts and specific copper demand shocks are negative for growth in the short-run. Gao et al. (2018) found that international metal price shocks directly affect industrial production and indirectly affect China's economic growth. These indirect effects are transmitted via a contractionary monetary policy on industrial inflation that is transmitted along the industrial chain. Wen et al. (2019) found that there is time variation between a copper price shock and China's Producer Price Index (PPI). In the short and medium term, copper price shocks significantly affect the PPI.
Shojaeinia (2023) found small and statistically significant coefficients in the price elasticities of supply and price elasticities of demand in the copper market in the long term. Consequently, with a small change in price there is a small change in the quantity demanded and supplied of copper in the US market.

In Perú, Larios-Meoño et al. (2021) analyzed the effects of the impact of copper mining on the main macroeconomic variables. The authors found that, in the long run, a 1% increase in the price of copper will produce a reduction in GDP of 0.25%. As such, the presence of Dutch disease in mining institutions could be explained. Additionally, Cardona-Arenas et al. (2024) analyzed the shocks in the precious metals composite price index on the main macroeconomic variables.

Considering the perspective of Okun's Law, the authors confirmed the importance of the dynamics of international precious metal prices and economic performance.

3 Hypothesis

3.1 General hypothesis

A positive shock to the international price of copper implies positive economic growth. There is no presence of the curse of natural resources in the extractive mining institutions of Junín in Peru.

3.2 Specific hypothesis

A positive shock in the international price of copper implies neutral inflation. Which does not cause major outbreaks of inflation in other sectors of the economy. Therefore, there is no loss of competitiveness and no natural resource curse in the extractive mining institutions of Junín in Peru.

4. **Methodology**

4.1 Population and sample

We have considered a quantitative approach, numerical measurement basis for the hypotheses. The level of research is explanatory, because there are hypotheses that seek to determine the cause and effects. The method is hypothetical deductive with a non-experimental and longitudinal trend design, the data are time series. We have established a sample of 132 observations, which began in January 2012 until December 2022. This is due to the INEI's slowness in making its data public for subsequent years. Within this sample, two sub-samples were carried out, the first before the pandemic, which consisted of the months of January 2012 until January 2020; and the second after the pandemic, which consisted of the months of February 2020 until December 2022.

Table 1
Main variables

Variable	Notation	Unit of measure	Source
Copper Price	pc_t	¢US$ per pound	BCRP
Junín's GDP Growth	GDP_t	Millions of constant soles of 2007	INEI
Junín's Prices	p_t	Index (2010=100)	INEI
Monetary Policy Rate	R_t	Percentage	BCRP

Table 1 shows the variables selected from the sample. We consider the average price of copper from the BCRP, which in turn is extracted from the London Metal Exchange (LME), then we extract the GDP at constant Junín prices, we extract the Junín GDP deflator that divides the GDP at current prices and the GDP at constant prices, finally we use the monetary policy rate which is a reference to all interest rates used in the financial system.

4.2 Data collection instrument

This research uses a set of data compiled from the thematic index of the INEI and the historical series of the BCRP, the data set corresponds to the validity of explicit inflation targets.

4.3 Econometric Model

We consider Amisano and Giannini (1997) and Lütkepohl (2005) to perform the SVAR model subject to constraints, which provides greater possibilities of obtaining consistent contrasts. Thus, we also consider Gali (1992), Gerlach and Smets (2011) and Peersman (2005) to identify four types of underlying disturbances, a copper price shock, an aggregate demand, an aggregate supply and a monetary policy shock. We can represent shocks using two strategies: the first is based on conventional short-run constraints and the second is based on long-run constraints.

Short-run SVAR model

$$\widetilde{\mathbf{A}}(\mathbf{I_K} - \mathbf{A_1} - \mathbf{A_2}\mathrm{L}^2 - \cdots - \mathbf{A_P}\mathrm{L}^\mathrm{P})\mathbf{Y_t} = \widetilde{\mathbf{B}}\mathbf{e_t} \tag{1}$$

where $\mathbf{Y_t} = [\Delta \mathrm{lnpc_t}, \Delta \mathrm{lno_t}, \Delta \mathrm{lnp_t}, \mathrm{R_t}]'$ is a (4×1) random vector, the $\mathrm{A_i}$ are fixed (4×4) coefficient matrices, the $\widetilde{\mathrm{A}}$ is a lower triangular matrix with ones on the diagonal, $\widetilde{\mathbf{B}}$ is a diagonal matrix and $\mathbf{e_t} \sim \mathrm{N}(\mathbf{0}, \mathbf{I_4})$ is a vector of structural disturbances. We consider four endogenous variables in $\mathbf{Y_t}$, copper price inflation (the first difference of the logarithm of the copper price), $\Delta \mathrm{lnpc_t}$, output growth (real percentage changes in GDP), $\Delta \mathrm{lno_t}$, inflation based on GDP deflator, $\Delta \mathrm{lnp_t}$, and the interest rate, $\mathrm{R_t}$.

Long-run SVAR model

$$\mathbf{Y_t} = \tilde{\mathbf{C}}\mathbf{e_t} \tag{2}$$

In the long-term modeling technique, traditional constraints are placed on the estimable parameters of the matrix $\tilde{C}$, which is diagonal.

4.4 Model Specification

We have imposed Cholesky constraints, using the constraints matrix $\widetilde{\mathbf{A}}$, $\widetilde{\mathbf{B}}$ y $\tilde{\mathbf{C}}$.

$$\widetilde{\mathbf{A}} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 \\ a_{41} & a_{42} & a_{43} & 1 \end{bmatrix} \quad \widetilde{\mathbf{B}} = \begin{bmatrix} b_{11} & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 \\ 0 & 0 & b_{33} & 0 \\ 0 & 0 & 0 & b_{44} \end{bmatrix}, \quad \text{and } \tilde{\mathbf{C}} = \begin{bmatrix} c_{11} & 0 & 0 & 0 \\ 0 & c_{22} & 0 & 0 \\ 0 & 0 & c_{33} & 0 \\ 0 & 0 & 0 & c_{44} \end{bmatrix} \tag{3}$$

We have mainly assumed that there is an immediate increase from a shock in the international price of copper on all other domestic macroeconomic variables, but we do not consider a significant impact of the other shocks on the international price of copper, because we consider a variable determined by the international market. In the next section, we have considered Granger (1969) and analyze the robustness of this assumption by using the Granger test.

5 Results

5.1 Variables

Table 2 shows the descriptive statistics, considering the 132 observations that represent all the months of the study sample. Copper price inflation has an average of 0.076% and a CV of 61.7184%, indicating a greater relative dispersion, it is negative asymmetric. Economic growth has an average of 0.3414% and a CV of 2.2873%, which indicates a low relative dispersion, it is negatively asymmetric. Inflation has an average of 0.2548% and a CV of 1.9333%, indicating a low relative dispersion, it is positively asymmetric. Also, all the variables are slightly leptokurtic.

Table 2
Descriptive statistics

	$\Delta \ln pc_t$	$\Delta \ln o_t$	$\Delta \ln p_t$	R_t
N	132	132	132	132
Max	14.0617	2.2977	1.9797	7.5000
Min	-18.1472	-1.9390	-0.7211	0.2500
Mean	0.0760	0.3414	0.2548	3.2765
SD	4.6906	0.7809	0.4926	1.5375
CV	61.7184	2.2873	1.9333	0.4693
P_{50}	-0.2052	0.2789	0.1968	3.5000
Skewness	-0.1600	-0.1338	1.3992	-0.3351
Kurtosis	4.4889	3.6114	5.5282	3.5874

Note. Author's elaboration using Stata 15 software. SD is the standard deviation and CV is the Coefficient of Variation.

5.2 Unit root test

Table 3 shows the correlations of the macroeconomic variables. All of them are moderately correlated except inflation and the interest rate, which have a negative linear correlation of 0.6727. This correlation increases the variance of the parameter estimates when modeling. However, the use of the interest rate in this model serves to ensure consistency in the dynamics of the pass-through effect of the copper price to Junín inflation.

Table 3
Correlation matrix

	$\Delta \ln pc_t$	$\Delta \ln o_t$	$\Delta \ln p_t$	R_t
$\Delta \ln pc_t$	1.0000	0.1525	0.2714	-0.1899
$\Delta \ln o_t$	0.1525	1.0000	0.1782	-0.1527
$\Delta \ln p_t$	0.2714	0.1782	1.0000	-0.6727
R_t	-0.1899	-0.1527	-0.6727	1.0000

Fig. 1 shows the main variables, the first subsample, before the pandemic, is to the left of the red line and the second subsample, after the pandemic, is to the right. Macroeconomic variables begin to recover after the pandemic, so the model could capture optimistic economic growth in the second sample after February 2020. Fig. 2 shows the graph of the dispersion matrix of each variable. It can be noted that there is a marked negative linear dispersion between nominal interest rate and inflation, this due to the explicit inflation targeting regime.

Fig. 1. Time series

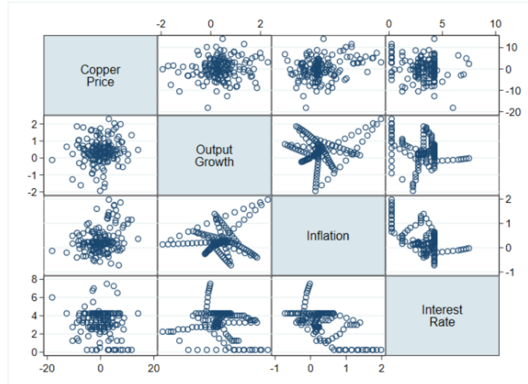

Fig. 2. Correlation matrix

5.2 Unit root test

Table 4 shows the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test. For $\mathbf{\Delta lnpc_t}$, $\mathbf{\Delta lno_t}$, $\mathbf{\Delta lnp_t}$, we can reject the null hypothesis of unit root at the 10% and 5% significance level (using the p-value of the ADF test), while the PP test turns out to be more restrictive. However, we cannot reject the null hypothesis at the 5% significance level in $\mathbf{R_t}$. Following Gali (1992) and Gerlach and Smets (2011), we assume that $\mathbf{R_t}$ is stationary within the samples used. Consequently, the vector of the main variables maintains a stationary process.

Table 4
Unit root test for stationarity

Series	Test	Statistic	p-value	Lag
$\Delta lnpc_t$	ADF	-3.096	0.0269	13
	PP	-9.293	0.0000	11
Δlno_t	ADF	-3.366	0.0122	13
	PP	-2.705	0.0731	11
Δlnp_t	ADF	-3.064	0.0293	13
	PP	-2.568	0.0999	11
R_t	ADF	-2.838	0.0531	13
	PP	-1.112	0.7102	11

Table 5 shows the conventional Granger test. We can note that the main domestic macroeconomic variables do not influence the international price of copper (p value of 0.241 before the pandemic and 0.197 after the pandemic). Which reinforces the use of the SVAR methodology and the imposition of a matrix of restrictions.

Table 5
Granger Causality Test

Equation	Excluded	χ^2	df	p-value
		Sample: 2012m1 - 2020m1		
$\Delta lnpc_t$	All other variables	7.960	6	0.241
Δlno_t		19.236	6	0.004
Δlnp_t		4.085	6	0.665
R_t		25.396	6	0.000
		Sample: 2020m2 - 2022m12		
$\Delta lnpc_t$	All other variables	8.599	6	0.197
Δlno_t		16.345	6	0.012
Δlnp_t		16.000	6	0.014
R_t		29.075	6	0.000

Table 6 shows the Akaike information criterion (AIC), the Hannan-Quinn information criterion (HQIC) and the Schwarz Bayesian information criterion (SBIC). The first two criteria similarly penalize model complexity, while the third is parsimonious and severely penalizes more complex models. Consequently, we consider the SBIC that indicates that, for the three samples, the optimal lag of the SVAR model to use is 2.

Table 6
Information Criteria Lag Selection

Lag	AIC	HQIC	SBIC
	Sample: 2012m1 - 2020m1		
0	9.5604	9.6033	9.6666
1	-1.8674	-1.6528	-1.3365
2	-3.9755	-3.5891*	-3.020*
3	-3.9882*	-3.4301	-2.6079
4	-3.8351	-3.1052	-2.0301
5	-3.7066	-2.8050	-1.4769
	Sample: 2020m2 - 2022m12		
0	14.088	14.1493	14.2657
1	-0.5786	-0.2718	0.3101
2	-1.4679	-0.9157	0.1318*
3	-1.8870	-1.0893	0.4238
4	-2.4208	-1.3777*	0.6010
5	-2.5799*	-1.2913	1.1530
	Sample: 2012m1 - 2022m12		
0	12.6970	12.7324	12.7843
1	2.3917	2.5692	2.8285
2	-0.7126	-0.3931*	0.0736*
3	-0.7687*	-0.3072	0.3670
4	-0.7060	-0.1026	0.7790
5	-0.7634	-0.0180	1.0711

* Optimal lag choice.

5.3. SVAR results

Table 7 shows the results of the parameter estimates of the short-run (before and after the pandemic) and long-run traditional restrictions matrices. We can note that the Z statistic is significant in most of the coefficients (p-value less than 0.005), the models are stable, the residuals are not normal, there is no autocorrelation at the tenth lag and there are no indications of model misspecification.

Table 7
SVAR (2) model results

	Coefficient	SE	Z	p-value	CI (95%)	
			Sample: 2012m1 - 2020m1			
$\mathbf{a_{21}}$	0.0003	0.001	0.190	0.846	-0.002	0.003
$\mathbf{a_{31}}$	0.0005	0.001	0.990	0.324	-0.001	0.002
$\mathbf{a_{41}}$	0.0006	0.002	0.260	0.798	-0.004	0.005
$\mathbf{a_{32}}$	0.3568	0.042	8.470	0.000	0.274	0.439
$\mathbf{a_{42}}$	-0.3134	0.239	-1.310	0.191	-0.783	0.156
$\mathbf{a_{43}}$	-0.6968	0.438	-1.590	0.111	-1.554	0.161
$\mathbf{b_{11}}$	3.8093	0.273	13.930	0.000	3.273	4.345
$\mathbf{b_{22}}$	0.0486	0.003	13.930	0.000	0.042	0.055
$\mathbf{b_{33}}$	0.0202	0.001	13.930	0.000	0.017	0.023
$\mathbf{b_{44}}$	0.0869	0.006	13.930	0.000	0.075	0.099
	Normality			0.000		
	Autocorrelation (10)			0.601		
			Sample: 2020m2 - 2022m12			
$\mathbf{a_{21}}$	-0.0010	0.003	-0.350	0.728	-0.006	0.005
$\mathbf{a_{31}}$	0.0001	0.000	0.260	0.793	-0.001	0.001
$\mathbf{a_{41}}$	-0.0142	0.004	-3.150	0.002	-0.023	-0.005
$\mathbf{a_{32}}$	-0.6205	0.019	-33.080	0.000	-0.657	-0.584
$\mathbf{a_{42}}$	-4.2324	1.528	-2.770	0.006	-7.228	-1.237
$\mathbf{a_{43}}$	-0.0010	0.003	-0.350	0.728	-0.006	0.005
$\mathbf{b_{11}}$	5.1860	0.006	8.370	0.000	0.040	0.064
$\mathbf{b_{22}}$	0.0863	0.000	8.370	0.000	0.001	0.001
$\mathbf{b_{33}}$	0.0096	0.000	8.370	0.000	0.000	0.000
$\mathbf{b_{44}}$	0.1373	0.000	8.370	0.000	0.001	0.002
	Normality			0.000		
	Autocorrelation (10)			0.834		
			Sample: 2012m2 - 2022m12			
$\mathbf{c_{11}}$	9.4794	0.583	16.250	0.000	8.336	10.623
$\mathbf{c_{22}}$	1.8132	0.112	16.250	0.000	1.594	2.032
$\mathbf{c_{33}}$	3.7544	0.231	16.250	0.000	3.302	4.207
$\mathbf{c_{44}}$	22.4989	1.385	16.250	0.000	19.785	25.213

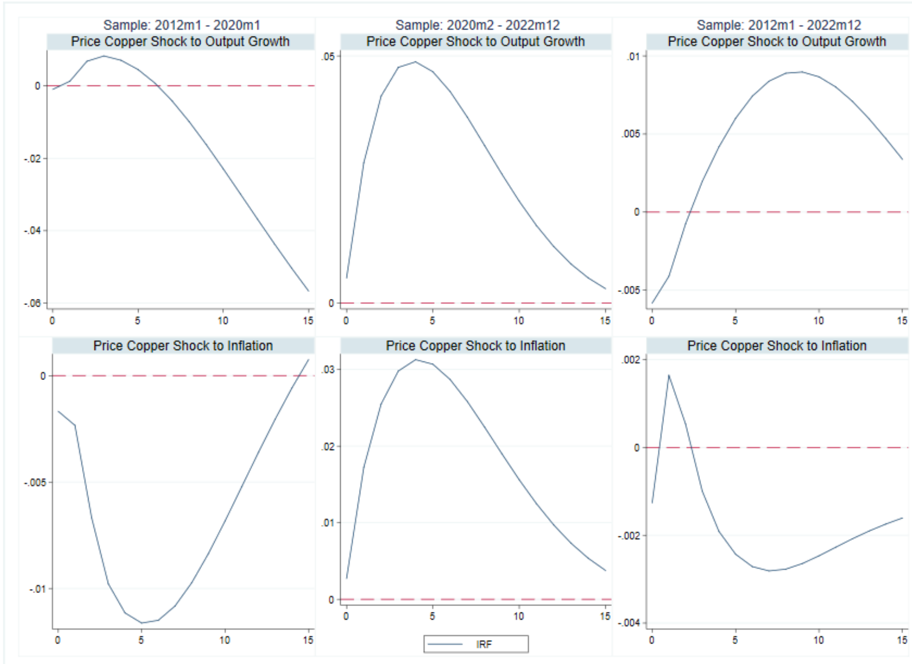

Fig. 3. IRF

Fig. 3 shows the impulse response function (IRF) of the international copper price shock to economic growth and inflation in Junín. In the short term, before the pandemic until the first month of 2020, an increase of one percentage unit in the price of the mineral under consideration, the price of copper, will cause a decrease in economic growth, then generates a considerable recovery captured by the commodity boom until the sixth month, the following months economic growth becomes permanently negative. After the pandemic, an increase of one percentage unit in the price of the mineral under consideration, the price of copper, will cause an increase in Junín's economic growth of up to 0.0488% in the fourth month, and then decrease over time. In the long-run, an increase of one percentage unit in the price of the mineral under consideration, the price of copper, will cause a decrease in Junín's economic growth until the second month, then a considerable recovery is generated captured by the economic recovery of greater global demand for minerals, which will then be dissipates over time. In turn, before the pandemic, a positive impact of one percentage unit of the price of copper will cause a decrease in inflation. After the pandemic, the same impact causes an increase in inflation of up to 0.0313% in the fourth month.

5.4. Contrasting results

Consequently, an increase of one percentage unit in the price of the mineral under consideration, the price of copper, has a negative impact on economic growth before the pandemic and a positive impact of up to 0.0488% after the pandemic. While, in the long term, the commodities boom is not enough to transform Junín's productive structure, achieve sustained economic growth and make it more competitive. Therefore, we can reject the general hypothesis, confirming that there is a presence of the curse of mining resources in the extractive mining institutions of Junín in Peru. In addition, we can also reject the alternative hypothesis, a copper price shock is not neutral on inflation and after the pandemic it can generate a positive pass-through effect on domestic inflation in Junín in Peru of up to 0.0313%. Which, added to lower economic growth, leads to poor competitiveness in other sectors outside of mining.

6 Discussion and conclusion

In this document we have estimated SVAR models that relate the price of copper and economic growth in various time periods, we choose the optimal lags to later (using Cholesky restrictions) obtain our result. Finally, the IRFs were estimated, which is the tool that allowed us to draw conclusions and results about the dynamics of the copper price, economic growth and inflation of Junín in Peru. In the short-run, before the pandemic, an increase of one percentage unit in the price of copper will cause a permanent drop in Junín's economic growth. After the pandemic an increase of one percentage unit in the price of the mineral under consideration, the price of copper, will cause an increase in Junín's economic growth of up to 0.0488% in the fourth month. Furthermore, after the pandemic, there is a positive pass-through effect with higher inflation, which can lead to low competitiveness in sectors such as agriculture and manufacturing. That is an argument in favor of the so-called natural resource curse existing. Therefore, if reforms are not made, the economic growth and price stability gained in recent years may be fallacious. We can point out that the economic growth of Junín in Peru is also conditioned by other factors, such as fiscal policies, monetary policies, global demand for other commodities, political stability and the quality of infrastructure, among others. Junín is one of the main copper-producing departments within Peru, and this metal represents a substantial part of its exports and tax revenues, which should be reflected in sustained economic growth. To mitigate the effects of the curse of mining resources on extractive institutions, Junín can implement economic policies such as diversifying its productive base, promoting innovation and investing in sectors unrelated to natural resources.

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