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ARTÍCULO

THE PERUVIAN MINING BOOM AND DUTCH DISEASE. EMPIRICAL EVIDENCE FROM 2003 TO 2020

Elmer Sánchez Dávila

Sánchez Dávila, E. (2023). The Peruvian mining boom and Dutch disease. Empirical evidence from 2003 to 2020. *Cuadernos de Economía*, *42*(90), 629-650.

The aim of this paper is to verify whether Peru has suffered from Dutch disease. To do this, a VARX model with monthly data from 2003 to 2020 is used to analyze whether the mining boom prices of the 2000s and 2010s have had a negative impact on the real sector, especially on non-primary manufacturing. Results show that a real exchange rate shock explains 8.2% of the variation in non-primary manufacturing. Even though the effect is significant, it is relatively small, and this is due to the Peruvian Central Bank intervening to reduce exchange rate volatility.

Keywords: Dutch disease; VARX estimation; mineral price boom; Peru.
JEL: F31, F4, E52 C32.

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Sánchez Dávila, E. (2023). El *boom* minero peruano y la enfermedad holandesa. Evidencia empírica del 2003 al 2020. *Cuadernos de Economía*, *42*(90), 629-650.

El objetivo de este artículo es verificar si Perú ha sufrido una enfermedad holandesa. Para ello se utiliza un modelo VARX con datos mensuales de 2003 a 2020 para analizar si el *boom* minero de las últimas dos décadas ha tenido un efecto negativo en el sector real, especialmente en manufactura no primaria. Los resultados muestran que un *shock* de tipo de cambio real explica el 8,2 % de la variación en la manufactura no primaria. Aunque existe un efecto significativo, este es pequeño, y esto debido a que el Banco Central de Perú interviene reduciendo la volatilidad del tipo de cambio.

Palabras clave: enfermedad holandesa; estimación VARX; auge de precio de los minerales; Perú.
JEL: F31, F4, E52, C32.

INTRODUCTION

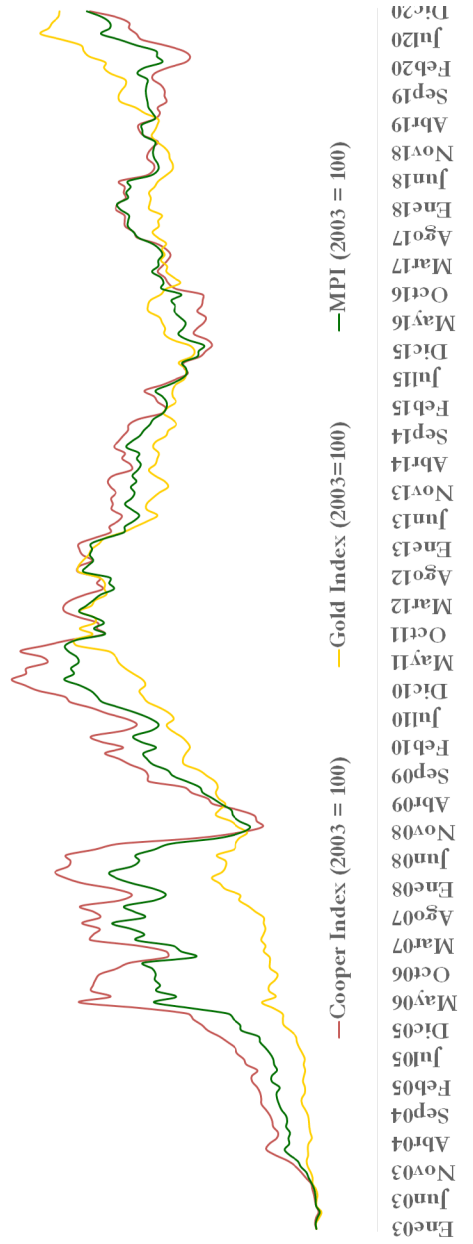
Peru has historically been a country with an economy heavily focused on mining. According to data from the Central Reserve Bank of Peru (CRBP), from 2003 to 2020, 58.1% of the country's total exports came from the mining sector, with the most important products being copper and gold (24.3% and 19.4% of total exports, respectively), but also zinc (4.8%), lead (3.8%), molybdenum (1.9%), iron (1.4%), silver (1.1%) and other mined products (1.4%). Since the turn of the millennium, there has been a boom in mining product prices due to heightened demand from China (Orihuela & Gamarra, 2018, p. 8). Figure 1 shows the evolution of copper and gold price indexes, and the Mineral Price Index (MPI) for Peru, which is constructed by multiplying the price of each mineral by their respective contribution to Peruvian mining GDP. The boom from 2003 to 2020 can be divided into two periods: the boom proper took place between 2003 and 2011. Then, between 2012 and 2020, the high prices stabilized. For instance, in the first period, the price of copper increased by almost 500% and gold by 400%, while in the second period, their prices stabilized to around a 250% increase of their 2003 prices.

While the mining boom prices have been beneficial for the Peruvian economy, this steady growth in prices could have a negative impact on the real sector. That is to say, the boom increases mining exports, which is followed by an appreciation in the exchange rate. This could then lead to less profitability for other economic sectors. An extended appreciation could be detrimental, as the country would face the risk of deindustrialization, especially for non-primary manufacturing. This is commonly known as Dutch disease. According to the economists Brahmbhatt, Canuto and Vostroknutova from the World Bank (2010, p. 1): "This term refers to changes in the structure of production that are predicted to occur in the wake of a favorable shock, such as a discovery of a large natural resource or a rise in the international price of an exportable commodity that is perceived to be permanent".

The term originates from the appreciation of the Dutch currency in the late 1950s and early 1960s due to the discovery and boom of natural gas exports, which reduced the competitiveness and profitability of manufacturing and service exports (Gylfason, 2001, p. 2). It was not until the 1980s however when the term was formalized in academic texts, in classic articles by Buiter and Purvis (1980), Corden and Neary (1982), and Bruno and Sachs (1982). In theory, the boom expansion of any commodity will be followed by an appreciation that could crowd out other manufacturing exports, running the risk of potential deindustrialization.

Figure 2(a) shows the negative relationship between the Mineral Price Index (MPI) and the exchange rate, which lend evidence to the theory that Peru's mining boom prices could have had an appreciation effect on the exchange rate. The coefficient of correlation between both variables is -0.70, which indicates a high inverse correlation. Figure 2(b) shows the relationship between the exchange rate and the logarithm of non-primary manufacturing. Its coefficient of correlation is -0.54, which

Figure 1.
Copper, Gold and Mineral Price Index Evolution, 2003–2020



Source: Compiled by the author based on FRED data.

indicates that an appreciation is associated with higher levels of production. This could evidence the absence of Dutch disease.

Figure 2(a).
Relationship between MPI and Real Exchange Rate, 2003–2020

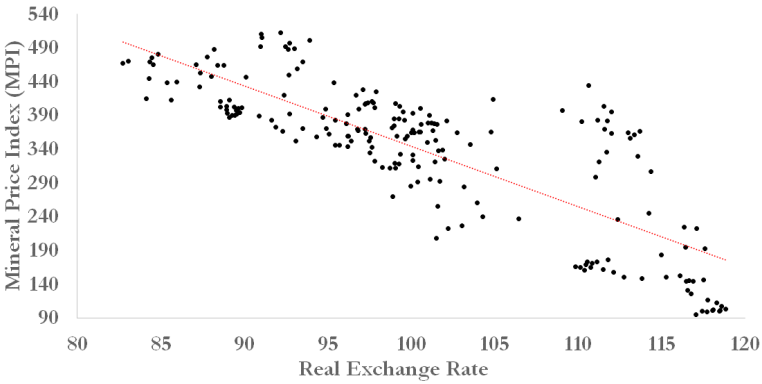
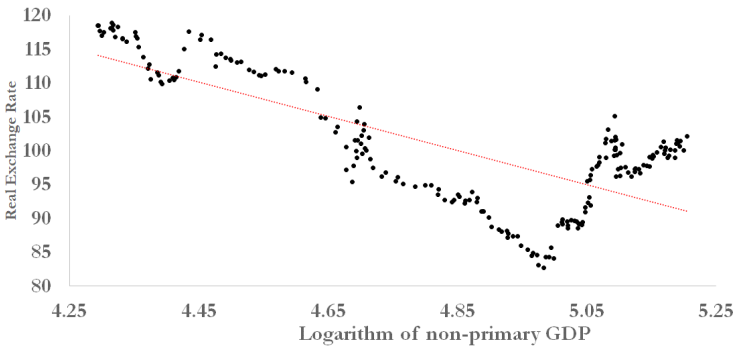


Figure 2(b).
Relationship between Exchange Rate and Non-primary Manufacturing, 2003-2020.



Source: Compiled by the author based on FRED and CRBP data.

The main objective of this paper is to determine whether the Peruvian economy has experienced Dutch disease over the last two decades. To do this, it is crucial to establish whether the manufacturing and service sectors have been affected by the appreciation of the exchange rate caused by the mining boom prices between 2003 and 2020. The principal hypothesis is that Dutch disease has not occurred in Peru due to the role that the Central Reserve Bank of Peru (CRBP) has played in the exchange market. The CRBP has a policy of intervention in the exchange market with the aim of reducing volatility. When there is a massive inflow of dollars to

Peru, the CRBP intervenes in the exchange market, buying some of the additional dollars circulating in the economy. On the other hand, when there is a massive outflow of dollars from the country, the CRBP intervenes in the exchange market using dollars from its reserve. The aim of this intervention is to reduce volatility in order to prevent any effect on the real sector.

LITERATURE REVIEW

International evidence

The international empirical evidence is wide-ranging and non-conclusive. There are some countries with no evidence of having had Dutch disease, and others that show signs of having suffered from it. For instance, Lanteri (2015) studied the effects that external shocks had on trade, supply of the agricultural sector (the booming sector) and real exchange rate on the real GDP of the manufacturing sector in the Argentine economy. For that purpose, he used VAR models with long-term restrictions with quarterly data from 1993 to 2015. He concluded that the manufacturing sector did not contract due to an improvement in terms of trade, nor to an appreciation in the real exchange rate; therefore, there is no substantial evidence to prove that this economy underwent Dutch disease.

Likewise, Ito (2019) did not find any evidence of Dutch disease in Georgia. By means of a Vector Error Correction Model (VECM) with quarterly periodicity from 2000 to 2016, the author found evidence that an inflow of remittances led to an appreciation of the real exchange rate in the long term, but in the short term had the reverse effect, due to an increase in imports which mitigated the existence of Dutch disease.

Bjornland (2003) also studied the economic effects of the energy booms of the oil and gas sectors on manufacturing output in Norway and the UK with quarterly data from 1976 to 1994. She used a structural VAR model to estimate the effects on manufacturing production of four uncorrelated structural shocks: energy booms, real oil price shocks, aggregate demand shocks and aggregate supply shocks. The results for Norway show that energy booms and an increase in oil prices stimulated manufacturing production, and so there was no evidence of Dutch disease. While the UK responded positively during the first few years of the energy booms, in the long term it showed some evidence of Dutch disease, however, the effect is small. In both countries, demand and supply shocks both show the effects predicted by economic theory.

Meanwhile, there are other papers that have found evidence of Dutch disease. For example, Desfrancois (2019) studied the evidence for the occurrence of Dutch disease in recent Ecuadorian history using a VAR-X model with quarterly data from 2000 to 2017. The aim was to analyze how a shock in oil prices (the booming sector) affected the real exchange rate which had caused a period of deindustrialization. He concluded that an appreciation of the real exchange rate caused a recession in the

manufacturing sector that persisted for 5 consecutive quarters. In other words, the appreciation of the real exchange rate crowded out the activity of the tradable sector, while the shock also caused fiscal and commercial imbalances in the country.

Sarmiento and López (2016) studied the process of deindustrialization that the Colombian economy underwent from 2002 to 2014 due to an oil boom. The aim of their paper was to analyze the effect that real exchange rate has on tradable and non-tradable goods. They found that the appreciation had a negative effect on the profitability of tradable goods and manufacturing, and a positive effect on the profitability of non-tradable goods. The authors also used dynamic panel data from 2002 to 2014 for 3,385 companies to show the heterogenous effects of deindustrialization – in terms of the size of firms – due to the oil boom. They found that when profits from tradable goods decline, small firms are more affected by the appreciation. Similarly, López *et al.* (2016) sought to demonstrate the hypothesis that Colombia has suffered from Dutch disease and deindustrialization. They found evidence of symptoms of Dutch disease, and so conclude that the mining and energy boom have potentially had adverse effects on the manufacturing sector.

Using dynamic panel data methodology, Abdlaziz, Naseem and Slesman (2018) studied the long-term relationship between oil prices and the agriculture sector in 25 oil-exporting countries from 1975 to 2014. They used three cointegration estimators: FMOLS, DOLS and PMG. They found that a 1% increase in oil price leads to a significant decrease in agricultural output, with reductions of 23%, 20% and 12% recorded by each cointegration estimator respectively. Meanwhile, a 1% decrease in the real exchange rate had a negative and significant impact, causing reductions of 14%, 11% and 38%, respectively. These results indicate the existence of Dutch disease and de-agriculturalization in oil-exporting economies.

Wong and Petreski (2014) used panel data for Latin American Countries (LAC) from 1990 to 2010. They concluded that China has played an important role in the commodity boom prices of LAC and that exchange rate overvaluation has been the channel through which the boom has affected the manufacturing sector. However, they concluded that effects on the manufacturing sector can be positive or negative: it depends on the type of manufacturing industry and country. Using diverse methodologies over different time periods and countries, other papers have obtained evidence of Dutch disease. Examples of this include Koitsiwe and Adachi's (2015) study which used a VAR model with annual data from 1975 to 2013 for the Australian economy, and a paper by Rudd (1996) which used Ordinary Least Squares (OLS) for the Netherlands, Nigeria and Indonesia between 1960 and 1990.

Additionally, some papers have evidenced a boom in commodity prices, an exchange rate appreciation, and a manufacturing decline in their countries of study, but these symptoms were not enough to suggest the presence of Dutch disease. For instance, Oomes and Kalcheva (2007) showed that in the Russian economy, higher oil prices led to faster real appreciation. They found no evidence of an overvalued real exchange rate. While they demonstrated that the manufactur-

ing sector declined in terms relative to the service sector, they concluded that this could also be the result of a "transition effect".

It is important to mention that the reviewed literature, so far, has studied the impact of Dutch disease on the aggregated data of industrial activities, grouping them into manufacturing, non-primary or tradable sectors. However, this aggregated data approach could show mitigated effects of Dutch disease on specific sectors. For this reason, it is important to also assess the effect of aggregated variables (such as the exchange rate) on the production of certain industrial goods, which depend on the position of these sectors in the respective Global Value Chains (GVC).

For instance, Landa (2020) studied industrial policy geared toward generating added value in countries with abundant Natural Resources (NRs). He categorized horizontal policies as those aimed at maintaining monetary stability, fiscal balance, and external equilibrium. Vertical policies are those intended to improve infrastructure and human capital. He argues that research on the global effects of the commodity boom prices between 2005 and 2015 should not only focus on aggregated data, but should also assess the impact that they have had on the global value chain of each country. He found that horizontal policies alone do not effectively promote the generation of value added in the industrial sector in economies with abundant NRs, and concludes that these must therefore be accompanied by instrumental policies that promote GVC. Similarly, Hiroyuki and Lar (2015) have argued that two-way trade integration promotes international production networks that in turn foster global value chains.

Evidence for Peru

Although the theory of Dutch disease dates from the late 1950s and early 1960s, studies on the Peruvian economy do not provide enough empirical evidence to definitively establish the presence of the disease. One of the few studies that provides empirical evidence is that conducted by Germán Vega (2014), who studied whether the prices boom has caused Dutch disease. The results of a Dynamic Stochastic General Equilibrium Model (DSGE) fed quarterly data from 1994 to 2012 give evidence of Dutch disease in Peru's economy. However, its magnitude was smoothed out by the influence of fiscal policy measures. Alarco (2011), however, obtained different results, finding no evidence of Dutch disease. Since the boom started, there has been an exchange appreciation, but it has not caused deindustrialization. He argues that this can be proven by the increase in both traditional and non-traditional (which includes manufacturing) exports. Another reason he gives is the monetary policy rule followed by the Central Reserve Bank of Peru, which has intervened in the exchange market and reduced its volatility.

Similarly, Ana María Whittembury (2012) conducted a study to discover whether the Peruvian economy suffered from at least some form of Dutch disease between 2001 to 2011. She analyzed four main variables: real exchange appreciation, slowdown in manufacturing output and service sector production and income growth. She concluded that the mining prices boom led to a real exchange appreciation.

However, she found no evidence of a decline in manufacturing production nor in the service sector at any point during the commodity prices boom. The study also found that income increased across all sectors. From these results, Whittembury found no evidence of Dutch disease in the 2001 to 2011 period.

Lastly, Orihuela and Gamarra (2018) studied the economic impact of natural resource-based development and its effect on Peru's national development from 2001 to 2015. The authors explored the hypothesis that the boom generated an exports specialization in commodities, which lead to higher macroeconomic volatility and finally to Dutch disease. The results show that export specialization in minerals lead to higher vulnerability to external shocks, including macroeconomic shocks. However, export specialization does not always increase as a result of the boom, which means that there is no real pattern of Dutch disease. Sergio Cruz (2011) produced the same results. These studies agree that while Peru is a country with an economy based on mining, the mining prices boom over the last two decades has not caused Dutch disease. This is due to its economic policy which has brought macroeconomic stability. Specifically, the monetary policy has played an important role in controlling exchange rate volatility, while the fiscal policy demonstrated countercyclical behavior.

METHODOLOGY

Data

The time series data for the analysis covers monthly data from January 2003 to February 2020. The data for mining GDP, real exchange rate, non-primary manufacturing and the net purchase of foreign currency was drawn from the Central Reserve Bank of Peru (CRBP). Additionally, I included the Index of Global Real Economic Activity created by the Federal Reserve Bank (FRED) to take into consideration the real market channel. Finally, I also use a dummy variable to represent the Global Financial Crisis of 2008.

Table 1.
Descriptions of the variables

Variable code	Variable description and treatment	Variable condition
lgdp_min_sa	Log. of the mining GDP (seasonally adjusted)	Endogenous
lrer	Log. of the real exchange rate	Endogenous
l_mannonpri_sa	Log. of the non-primary manufacturing (seasonally adjusted)	Endogenous
crbp_int	Net purchase of foreign currency	Exogenous
igrea	Index of Global Real Economic Activity	Exogenous
dummy	Dummy for Global Financial Crisis of 2008	Exogenous

In the period of analysis used in this study, the mining sector represented, on average, 13.6% of total GDP. Broken down, this number comprises copper production (43.4% of total mining GDP), and that of gold (33%), zinc (7.9%), lead (6.8%) and tin (2.4%). Non-primary manufacturing represented on average 76.4% of total GDP. I use the real exchange rate here instead of the nominal exchange rate because I am interested in the real effects caused in the other sectors. These variables are treated as endogenous variables and are measured in real indexes. Crbp_int is an exogenous variable that represents the net purchase of foreign currency, in other words, it stands for the intervention of the CRBP in the exchange market with the aim of reducing volatility. Finally, igrea is an exogenous variable which is an updated index of global real economic activity in industrial commodity markets. Kilian and Zhou (2018) propose that this index be used as proxy for the volume of shipping in global industrial commodity markets. This variable is highly correlated with global economic GDP.

Econometric methodology

This paper seeks to establish whether there has been Dutch disease in the Peruvian economy. In order to do this, the effects of the mining boom from 2003 to 2020 on the real exchange rate must be estimated. Then, I will determine if non-primary manufacturing has been affected using an unrestricted VAR methodology. The VAR approach offers various methods to evaluate the existence of the tested relationship and to quantify its effects. The VAR methodology can also analyze the Impulse Response Functions (IRFs) and the Variance Decompositions (VDCs) of different shocks (Canova, 1999; Enders, 2015). The VAR methodology can be expressed as:

$$Y_t = \alpha + \sum_{i=1}^{p} \pi_t Y_{t-i} + \sum_{i=0}^{m} \varphi_t X_{t-i} + \varepsilon_t$$

Where Y_t is a vector of endogenous variables, π_t is a matrix of k autoregressive coefficients, X_t is a vector of exogenous variables and φ_t is a matrix of q coefficients for the exogenous variables. The error term, ε_t, is assumed to contain no serial correlation and have a covariance matrix.

The Cholesky decomposition sequence order is used to arrange the vectors of endogenous variables. The variables that appear first are considered less endogenous while those appearing last are considered more endogenous. Therefore, mining GDP is the least endogenous because its value and production are determined by the global market. Mining GDP will have an impact on the real exchange rate, and this, in turn, will have an impact on non-primary manufacturing.

Analysis procedure

Before conducting the estimations, the first step is to remove seasonal patterns. To do this, the seasonal adjustment Census X-13 is used in the logarithm of mining and non-primary manufacturing. Second, all endogenous variables must be checked for stationarity. This was undertaken by means of the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests. These tests were conducted to avoid misleading results that may be caused by the use of non-stationary time series data.

Third, if the endogenous variables are found to be integrated of order one $\left(I \sim (1)\right)$, it is necessary to test for cointegration. If not, I can proceed to estimate a VAR model. The trace and the max-Eigen value statistics tests from the Johansen cointegration test are used to prove the existence of a long-term relationship in the model. If the model has at least one cointegration order, a VEC model is used. If there is no cointegration at any order, a VAR model is used. To estimate the optimal lag in the model (see Appendix 1), I used the Akaike Information Criteria (AIC) and the Log-likelihood Ratio (LR). The last step of the estimation is to prove its global significance (see Appendix 2) and the stability of the VAR (see Appendix 3).

After estimation, I generated the Impulse Response Functions (IRFs) to illustrate how a particular variable responds to one standard deviation shock on each variable in the system. I also displayed the Variance Decomposition (VDCs) in a table to show, for each variable, the proportion of the forecast error variance that can be attributed to the variable's own shocks, and shocks originating from other variables in the system. Finally, I used a Granger causality test to determine whether changes in one variable cause changes in another variable.

EMPIRICAL RESULTS

Unit root test

One of the conditions of time series analysis is to examine the integrated order of each variable. Table 2 presents the stationarity results of the logarithm of mining GDP (lgdp_min_sa), real exchange rate (lrer), the logarithm of the non-primary manufacturing (l_mannonpri_sa), the net purchase of foreign currency made by the Central Reserve Bank of Peru (crbp_int) and the index of global real economic activity. The results show that all endogenous variables are stationary in their first differences (integrated of order 1), one of the exogenous variables is stationary in levels (integrated of order 0) and the other is in its first difference (integrated of order 1). As all the endogenous variables are integrated of the same order, a cointegration test can be performed.

Table 2.
Results of unit root test

	ADF (level)	ADF (1^{st} Δ)	PP (level)	PP (1^{st} Δ)	Order of Integration
lgdp_min_sa	-0.999 (0.7536)	-6.409 (0.000) ***	-1.022 (0.7453)	-26.057 (0.000) ***	*I*(1)
lrer	-1.773 (0.3937)	-5.146 (0.000) ***	-1.762 (0.3995)	-10.860 (0.000) ***	*I*(1)
l_mannonpri_sa	-1.190 (0.9125)	-4.604 (0.000) ***	-1.123 (0.9251)	-15.865 (0.000) ***	*I*(1)
crbp_int	-3.775 (0.0032) **	-	-6.675 (0.000) ***	-	*I*(0)
igrea	-2.363 (0.1526)	-8.083 (0.000) ***	-3.225 (0.0795) *	-12.003 (0.000) ***	*I*(1)

Four lags are used for all ADF tests. Values in parenthesis are the Mackinnon p-value. *** 1% significance level, ** 5% significance level.
Source: Calculated and compiled by the author.

Cointegration test

The trace statistics test and the max-Eigen statistics test for cointegration indicate that there is no long-term relationship between the endogenous variables in the system. Hence, a VARX estimation will be used.

Table 3.
Results of trace statistic test

Maximum Rank	Eigenvalue	Trace Statistic	5% critical value	Max Statistic	5% critical value
None	.	24.8588 *	29.68	16.2344 *	20.97
At most 1	0.06048	8.6244	15.41	7.8930	14.07
At most 2	0.03742	0.7314	3.76	0.7314	3.76

* Indicates rejection of the null hypothesis at the 5% level.
Source: Calculated and compiled by the author.

VARX estimation

To obtain the optimal lag of the VARX, I used the AIC and LR criteria (see Appendix 1). Both confirm that the optimal lag of the model is 6. With the optimal lag confirmed, I proceeded to estimate the VARX model. The Cholesky decomposition order for the endogenous variables is as follows: mining GDP (lgdp_min_sa) is the least endogenous variable, followed by the real exchange rate (lrer). Non-primary manufacturing (l_mannonpri_sa) is the most endogenous variable.

There is one exogenous variable included in the model, which is intervention by the CRBP in the exchange market (crbp_int).

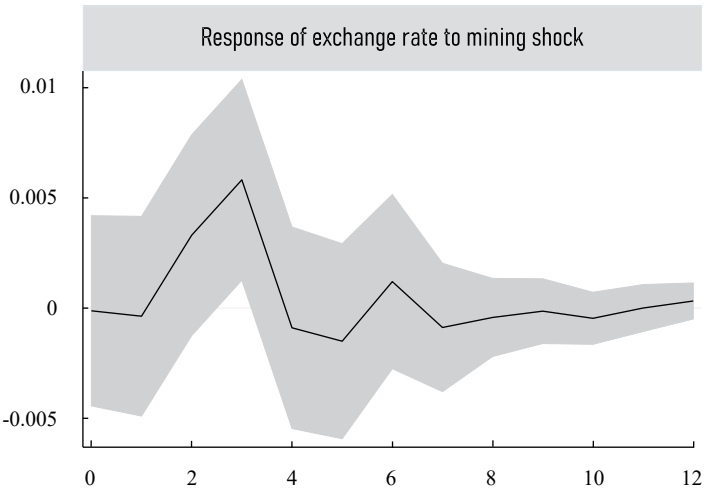
Appendix 2 shows the global significance of the VARX. From a global perspective, the VARX is statistically significant in all its lags. Similarly, Appendix 3 shows that all the eigenvalues lie inside the unit circle, which means that the VARX is stable. It is important to note that all variables have the expected signs. The exogenous variable, Central Bank intervention (crbp_int), is significant, which means that CRBP has played an important role in reducing exchange rate volatility. Additionally, the dummy variable for the Global Financial Crisis of 2008 shows that there has been a significant impact on the non-primary manufacturing sector and on the exchange rate in the Peruvian economy (see Appendix 4).

Impulse Response Functions (IRFs)

Figure 3 shows the IRFs of real exchange rate and non-primary manufacturing. It shows the response of one variable to a one standard deviation shock in another variable. The response of the exchange rate to a mining shock is positive in the first quarter, negative the following month and then the shock disappears. The behavior in the first quarter is explained by the lag length effect, while that of the second is due to appreciation.

The response of non-primary manufacturing to a mining shock is negative in the first month, followed by two months of positive impacts. After that, the shock stabilizes. On the other hand, the response of non-primary manufacturing to exchange rate is quite volatile. It is positive during the first month, negative for the second month, and positive again in the third month. After six months, the effect shrinks.

Figure 3.
Results of impulse response functions



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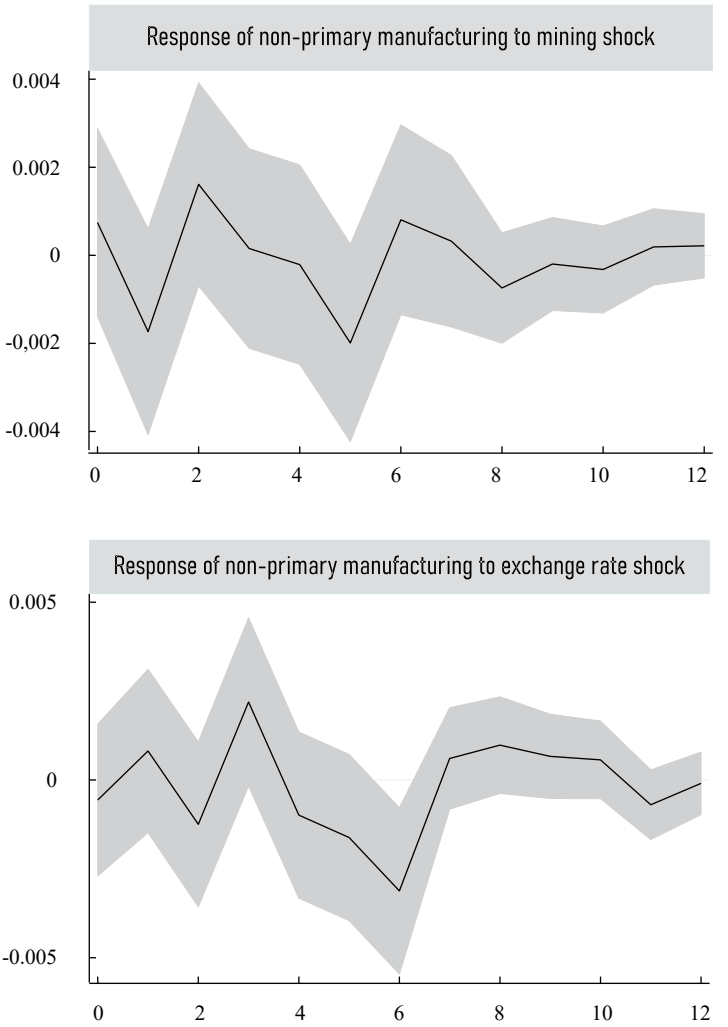


Source: Calculated and compiled by the author.

Variance Decomposition (VDCs)

The Variance Decomposition is the proportion of forecast error variance that is attributable to the shocks of the variable itself and those of other variables (see Table 4). The main finding is that the variables' own shocks constitute the predominant source of variation. At the end of the ten months, a real exchange rate shock explains 8.2% of variation in non-primary manufacturing, while a mining shock explains 3.8% of variation. However, while the impact of real exchange rate shock on non-primary manufacturing variation is significant, the effect is small. This is due to the CBRP reducing the volatility of the exchange rate. This

curbs its effect on the real sector of the economy. More specifically, this intervention has not allowed non-primary manufacturing to be harmed by the real exchange rate appreciation.

Table 4.
Variance Decomposition (VDC)

Step	VDC of Mining (MIN)			VDC of Exchange Rate (EXC)			VDC of Non-Primary Manufacturing (N-P)		
	ΔMIN	ΔEXC	ΔN-P	ΔMIN	ΔEXC	ΔN-P	ΔMIN	ΔEXC	ΔN-P
1	1.000	0.000	0.000	0.000	1.000	0.000	0.003	0.007	0.990
2	0.981	0.015	0.004	0.000	0.999	0.001	0.016	0.007	0.978
3	0.967	0.029	0.004	0.009	0.987	0.004	0.026	0.017	0.957
4	0.944	0.046	0.010	0.039	0.956	0.005	0.026	0.024	0.950
5	0.924	0.066	0.010	0.039	0.954	0.007	0.025	0.034	0.941
6	0.897	0.064	0.039	0.041	0.952	0.008	0.037	0.044	0.919
7	0.848	0.071	0.081	0.043	0.948	0.010	0.036	0.082	0.882
8	0.831	0.075	0.094	0.043	0.947	0.010	0.036	0.082	0.882
9	0.830	0.076	0.094	0.043	0.947	0.010	0.038	0.082	0.880
10	0.829	0.076	0.095	0.043	0.946	0.011	0.038	0.082	0.880

Source: Calculated and compiled by the author.

VARX Granger Causality

The Granger causality test shows that a variable will affect changes in another variable if past and present values of the former variable assist in predicting the latter variable. Therefore, it is important to examine the causality relationships among the three variables (see Table 5).

Table 5.
Results of VAR Granger causality

→ Granger cause	F	Prob > F	Null Hypothesis
Exchange rate → Mining GDP	1.8329	0.0951	Rejected
Non-primary Manufacturing → Mining GDP	2.9361	0.0094	Non-Rejected
Mining GDP → Exchange rate	2.9197	0.0353	Non-Rejected
Non-primary Manufacturing → Exchange rate	0.52498	0.7889	Rejected
Mining GDP → Non-primary Manufacturing	1.2282	0.2939	Rejected
Exchange rate → Non-primary Manufacturing	3.811	0.0013	Non-Rejected

To reject the null hypothesis (Ho: No Granger Causality) p-value < 0.05.
Source: Calculated and compiled by the author.

The results of Cholesky's decomposition reveal that the least endogenous variable is mining GDP, followed by the real exchange rate. The most endogenous variable is non-primary manufacturing. These results also indicate that there is endogeneity in the variables, which reinforces the decision to use a VAR methodology, as this method is used to estimate models where endogeneity is present. The results in Table 5 show that mining GDP Granger-causes the exchange rate, but it does not Granger-cause non-primary manufacturing. Also, the real exchange rate Granger-causes non-primary manufacturing; and non-primary manufacturing Granger-causes the mining GDP. From this, I can conclude that the mining boom has caused an appreciation of the real exchange rate. This mining boom has influenced non-primary manufacturing through the exchange rate, but it is not a direct influence.

Policy implications

The empirical results have shown that there has been an appreciation of the real exchange rate, however, this has been a small one. The role that the Central Bank has played in the exchange rate market has been essential to avoiding volatility and lending predictability to the exchange rate. As can be seen in Figure 4(a), when the exchange rate appreciated, the Central Bank intervened in the exchange market selling foreign currency to reduce its volatility. When it depreciated, the Central Bank bought foreign currency. Similarly, Figure 4(b) shows a negative relationship between net purchase of foreign currency and exchange rate growth. The greater the appreciation of the exchange rate, the more dollars the Central Bank sells, and vice versa. This shows that the role the Peruvian Central Bank has played in stabilizing the exchange rate has been fundamental to mitigating a significant impact of the mining boom on the exchange rate. From this, I can conclude that Dutch disease in Peru has been avoided.

Figure 4(a).
Central bank intervention and exchange rate

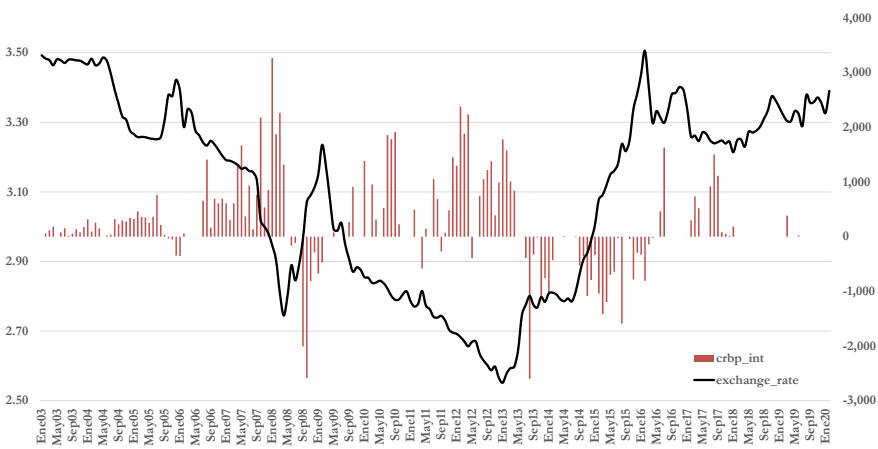
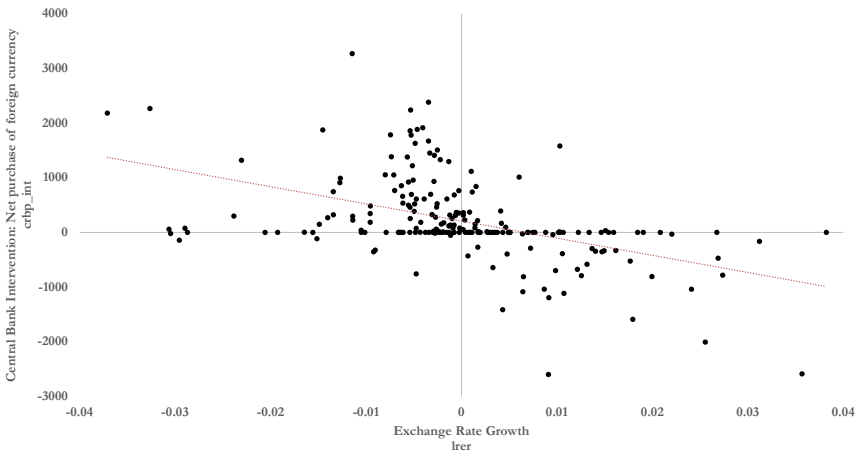


Figure 4(b).
Relationship between exchange rate and central bank intervention



Source: Calculated by the author based on CRBP data.

CONCLUSION AND POLICY RECOMMENDATIONS

The literature concerning Dutch disease shows that a boom in a tradable sector (especially primary goods) will have negative impacts on the economy of a country. This is due to a long-lasting real exchange rate appreciation that decreases the competitiveness of national manufacturing industries, which sooner or later will result in a process of deindustrialization.

There is also empirical evidence from around the world that demonstrates the impacts that Dutch disease may have on the overall economy of a country. Empirical conclusions are heterogenous: in some countries the disease might have a negative overall impact, whereas in others, a commodity boom does not seem to have caused Dutch disease at all. A review of this literature revealed that there is a lack of empirical evidence for the Peruvian economy in this area. This paper attempts to fill this gap.

The study used a VARX model to discover whether the Peruvian economy suffered from Dutch disease between 2003 and 2020. The VARX comprised three endogenous variables (mining GDP, real exchange rate and non-primary manufacturing) and three exogenous variables (Central Bank intervention in the exchange market, the index of global real economic activity and a dummy for the global financial crisis). Results of the variance of decompositions show that a real exchange rate shock explains 8.2% of the variation in non-primary manufacturing, while a

mining shock explains 3.8%, at the end of a ten-month period. This demonstrates that the mining boom caused an appreciation of the real exchange rate. The mining boom influenced non-primary manufacturing through the exchange rate; it did not have a direct influence. These results are also supported by Granger causality: mining GDP Granger-causes the exchange rate, but not non-primary manufacturing. Non-primary manufacturing is Granger-caused by the exchange rate.

The results from a robustness check conducted using a mineral price index are similar. Appendix 5 shows the variance decomposition of this model. Two other robustness checks were also carried out, one using a model with a variable of the terms of trade, and another with the global copper price. The results were also quite similar and are available upon request.

The evidence uncovered in this paper indicates that a real exchange rate shock explains 8.2% of variation in non-primary manufacturing. However, even though this impact is significant, it is also relatively small. This is due to the monetary policy implemented by the Central Reserve Bank of Peru, which reduced exchange rate volatility. This case shows that continual intervention in the exchange market is necessary to reduce volatility and avoid detrimental effects on the economy. Finally, the evidence suggests that Dutch disease in Peru has been avoided.

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REFERENCES

1. Abdlaziz, R., Naseem, N., & Slesman, L. (2018). Dutch disease effect of oil price on agriculture sector: Evidence from panel cointegration of oil exporting countries. *International Journal of Energy Economics and Policy, 8*(5)*,* 241-250. https://www.econjournals.com/index.php/ijeep/article/view/6723
2. Alarco, G. (2011). Exportaciones, tipo de cambio y enfermedad holandesa: el caso peruano. *Investigación Económica, 70*(275)*,* 115-143. http://dx.doi.org/10.22201/fe.01851667p.2011.275.24265
3. Bjornland, H. (2003). The economic effects of North Sea oil on the manufacturing sector. *Scottish Journal of Political Economy, 45*(5)*,* 553-585. https://doi.org/10.1111/1467-9485.00112
4. Brahmbhatt, M., Canuto, O., & Vostroknutova, E. (2010). *Dealing with Dutch disease.* The World Bank – economic premise. http://hdl.handle.net/10986/10174

5. Bruno, M., & Sachs, J. (1982). Energy and resource allocation: A dynamic model of the Dutch disease. *Review of Economic Studies, 8*(52), 1-38. http://doi.org/10.3386/w0852
6. Buiter, W., & Purvis, D. (1980). *Oil, disinflation, and export competitiveness: A model of the Dutch disease* [Working Paper N° 592]. National Bureau of Economic Research. http://doi.org/10.3386/w0592
7. Canova, F. (1999). Vector autoregressive models: Specification, estimation, inference and forecasting. In H. Pesaran & P. Schmidt (Eds.), *Handbooks of Applied Econometrics* (1st ed., pp. 53-110). Blackwell Publishers. https://doi.org/10.1111/b.9780631215585.1999.00003.x
8. Corden, W., & Neary, J. (1982). Booming sector and de-industrialization in a small open economy. *The Economic Journal, 92*(368), 825-848. https://doi.org/10.2307/2232670
9. Cruz, S. (2011). *The resource curse and Peru: A potential threat for the future?* [Unpublished master's thesis, University of San Francisco]. https://repository.usfca.edu/thes/4
10. Desfrancois, P. (2019). Evaluación empírica de los síntomas de la enfermedad holandesa en la historia ecuatoriana reciente (2007-2017). *Actualidad Económica 29*(97), 23-35. https://revistas.unc.edu.ar/index.php/acteconomica/article/view/24270
11. Enders, W. (2015). *Applied econometric time series* (4th Edition). Wiley.
12. Gylfason, T. (2001). *Lessons from the Dutch disease: Causes, treatment, and cures* [Working Paper Series No. 1(06)]. Institute of Economics Studies. https://www.researchgate.net/publication/277227867_Lessons_from_the_Dutch_disease_Causes_treatment_and_cures
13. Hiroyuki, T., & Lar, N. (2015). *Global value chains participation and industrial upgrading in Asian developing economies* [MPRA Paper No. 65708]. Munich Personal RePEc Archive. https://mpra.ub.uni-muenchen.de/65708/1/MPRA_paper_65708.pdf
14. Ito, K. (2019). Remittances and the Dutch disease: Evidence from Georgia. *Post-Communist Economies, 31*(4), 500-506. https://doi.org/10.1080/14631377.2018.1537733
15. Kilian, L., & Zhou, X. (2018). Modeling fluctuations in the global demand for commodities. *Journal of International Money and Finance*, *88*, 54-78. https://doi.org/10.1016/j.jimonfin.2018.07.001
16. Koitsiwe, K. & Adachi, T. (2015). Australia mining boom and Dutch disease: Analyzing using VAR method. *Procedia Economics and Finance*, *30*, 401-408. https://doi.org/10.1016/S2212-5671(15)01307-6
17. Landa, Y. (2020). Industrial policies of countries with abundant natural resources in the Association of Southeast Asian Nations and Pacific Alliance. *The Extractive Industries and Society, 7*(3), 1046-1053. https://doi.org/10.1016/j.exis.2020.07.004

18. Lanteri, L. (2015). Efectos de la enfermedad holandesa. Alguna evidencia para América Latina. *Revista de Economía del Rosario, 18*(2)*,* 187-209. https://doi.org/10.12804/rev.econ.rosario.18.02.2015.02
19. López, M., Torres, E., & Giraldo S. (2016). The evolution of Colombian industry in the context of the energy-mining boom: Symptoms of the Dutch disease? *Cuadernos de Economía*, *35*(68), 475-490. https://doi.org/10.15446/cuad.econ.v35n68.54255
20. Oomes, N., & Kalcheva, K. (2007). *Diagnosing Dutch disease: Does Russia have the symptoms?* [Working Paper No. 7/2007]. BOFIT. https://doi.org/10.2139/ssrn.1001659
21. Orihuela, J., & Gamarra, V. (2018). *Variegated dependence: The geographically differentiated economic outcomes of resource-based development in Peru, 2001–2015* [Working Paper No. 458]. PUCP. http://doi.org/10.18800/2079-8474.0458
22. Rudd, D. (1996). An empirical analysis of Dutch disease: Developing and developed countries. *Honors Projects*, *62*. https://digitalcommons.iwu.edu/econ_honproj/62/
23. Sarmiento, E., & López, M. (2016). Incidencia del tipo de cambio sobre la enfermedad holandesa de las ganancias de los bienes transables y no transables. *Centros de Estudios Monetarios Latinoamericanos,* (1)*, 45-81.* https://www.cemla.org/PDF/monetaria/PUB_MON_XXXVIII-01-02.pdf
24. Vega. G. (2014). *Enfermedad Holandesa y política fiscal en el Perú: un enfoque estructural de equilibrio general dinámico* [Unpublished undergraduate thesis, Universidad de Piura]. https://hdl.handle.net/11042/1977
25. Whittembury, A. M. (2012). Is the Peruvian economy suffering from Dutch disease? *Revista de Temas Financieros, 8*(1). https://www.sbs.gob.pe/Portals/0/jer/rebper_2012_vol_vi/20150914_Whittembury.pdf
26. Wong, S., & Petreski, M. (2014). *Dutch disease in Latin American countries: De-industrialization, how it happens, crisis, and the role of China* [Working Paper No. 57056]. Munich Personal Repec Archive. https://ideas.repec.org/p/pra/mprapa/57056.html

APPENDIX

Appendix 1.
Selection Order Criteria of the VARX

Lag	AIC	LR
0	-13.2124	
1	-13.4672	68.696
2	-13.5041	25.359
3	-13.4749	12.187
4	-13.4821	19.421
5	-13.5051	22.587
6	-13.5638 *	29.672 *

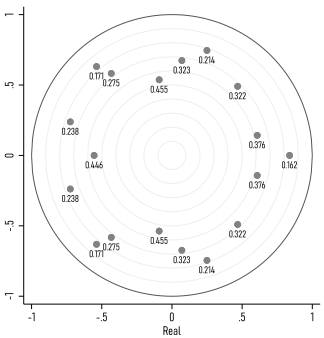
Source: Calculated and compiled by the author.

Appendix 2.
VAR Global Significance

Equation	Lag	F	Prob > F
ALL	1	11.6601	0.0000 ***
ALL	2	2.2423	0.0213 **
ALL	3	1.9659	0.0457 **
ALL	4	1.6026	0.0898 *
ALL	5	1.8228	0.0669 *
ALL	6	2.8134	0.0004 ***

Source: Calculated and compiled by the author.

Appendix 3.
VARX stability



Source: Calculated and compiled by the author.

Appendix 4.
Results of the Exogenous Variables in the VARX Estimations

	dlgdp_min_sa	**dlrer**	**dl_mannonpri_sa**
crbp_int	- 0.0000 (0.873)	-2.03 (0.000) ***	-0.36 (0.842)
digrea	0.0000 (0.955)	-0.0009 (0.372)	0.0001 (0.025) **
dum1	-0.0048 (0.711)	0.02707 (0.046) **	-0.0146 (0.049) **
constant	0.0058 (0.023) **	0.0013 (0.658)	0.0041 (0.005) ***

*** 1% significance level, ** 5% significance level. Values in parenthesis are the p-value.
Source: Calculated and compiled by the author.

Appendix 5.
Robustness Check - Variance Decomposition (VDC)

Step	**VDC Mineral Price Index (MIN)**			**VDC of Exchange Rate (EXC)**			**VDC of Non-Primary Manufacturing (N-P)**		
	ΔMIN	**ΔEXC**	**ΔN-P**	**ΔMIN**	**ΔEXC**	**ΔN-P**	**ΔMIN**	**ΔEXC**	**ΔN-P**
1	1.000	0.000	0.000	0.059	0.941	0.000	0.011	0.000	0.988
2	1.000	0.000	0.000	0.067	0.933	0.000	0.025	0.007	0.968
3	0.998	0.001	0.001	0.086	0.914	0.001	0.026	0.018	0.956
4	0.994	0.005	0.001	0.109	0.885	0.006	0.026	0.033	0.941
5	0.976	0.016	0.008	0.112	0.881	0.007	0.039	0.035	0.926
6	0.948	0.016	0.035	0.114	0.877	0.009	0.052	0.039	0.909
7	0.948	0.016	0.036	0.114	0.875	0.011	0.056	0.065	0.879
8	0.948	0.017	0.036	0.115	0.873	0.012	0.055	0.066	0.879
9	0.946	0.018	0.036	0.117	0.871	0.012	0.056	0.070	0.874
10	0.945	0.018	0.037	0.119	0.869	0.012	0.056	0.070	0.873

Source: Calculated and compiled by the author.

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