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Influence of Copper in the Peruvian Economy: A Review of the Last Century

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INFLUENCE OF COPPER IN THE PERUVIAN ECONOMY: A REVIEW OF THE LAST CENTURY

by

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A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
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RESEARCH PAPER APPROVAL

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TITLE: INFLUENCE OF COPPER IN THE PERUVIAN ECONOMY: A REVIEW OF THE LAST CENTURY

MAJOR PROFESSOR: Dr. Scott Gilbert

This paper analyses the long-term impact of the production of copper in the Peruvian economy in the past 100 years. The experiment will be implemented with a Time Series analysis finding statistical evidence of a relationship between the production of copper and total exports in the last 100 years. This concludes that Peru has been strongly dependent on the production of copper in the last century. Variables such as China's demand for the metal and historical political stability play an important role in the production of copper. The analysis also presents a review of the most important historical events that could represent the increasing relationship of copper and the economic growth of Peru.

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INTRODUCTION

Over the past 2 decades, Peru has seen a dramatic change in its economy. With GDP and GDP per capita constantly increasing at a considerably higher rate than in many other neighbor countries. Political stability and increasing foreign investment have been important determinants to economic expansion. But Peru is still a country very dependent on external variables. According to data of MINEM (Ministry of Energy and Mines of Peru) suggests that Mining activities is the second biggest variable in the GDP structure of Peru after Services which conveys 50% of GDP. Mining activities are highly related to external variables as most of its production is exported to many different countries.

Mining activities has increased drastically in the last few years in Peru. The production of minerals such as gold, silver, copper, and zinc are just a few of the minerals being produced that convey 14% of the GDP structure of Peru. But just copper has become the most significantly important mineral in the last 5 years. In 2017, just copper mining activities, produced and exported around 14 billion dollars. It is a relatively high number considering Peru's GDP was about 200 billion dollars that year. Copper in Peru has served mainly as a source of revenue on exporting activities. Historically, the production of copper has had the same amount extracted as exported, meaning all the copper produced is being exported. Among the countries with the highest copper demand in the last few years is China. China is Peru's larger trading partner in the copper industry. In 2017, just exports to China were about 8 billion dollars (60% of total copper exports). Other Asian countries like Japan and South Korea, also had considerably high demand for the metal, with 1 billion and 800 million dollars' worth respectively. But not nearly close as

China. China's increasing investments also reflect a dependency on the Peruvian economy of external variables such as their demand for the metal.

Even though China's demand for copper has become a crucial factor for the copper industry and economy of Peru in the twenty-first century, it is not as clear when analyzing the Peruvian copper production growth over a much longer period of time. Figure 1.1 shows the growth in the copper production over the last 100 years. The copper industry was very unstable up until the mid 1950s when a huge increase in the production of copper as well as other metals arise. There was a slowdown in the 1970s because of strong political instability. But in the 1980s the copper industry started to increase once again and continued to grow until today.

The boom in the copper industry of the mid 1950s was because of the creation of the new Mining Code of 1950 which generated significant changes in the mining industry. The economic incentives brought foreign capital into the country. An example is the expansion of the Toquepala mine which was considered one of the biggest mines in the world at the time. The good setting for the investment and the high mineral prices also had a positive impact. The slowdown of the copper and mining industry in the 1970s arrived because of the coup in 1968 where the army led by Juan Velasco Alvarado took over the presidency. His reforms aim to nationalize important mining operations and companies like Southern Peru and Cerro Verde (most important mining companies at the time), which highly damaged the mining industry. The economic slowdown, high inflation, and very low prices of metals also negatively affected the industry. It was not until the 1990s where the mining industry in Peru flourish once again as new president Alberto Fujimori started a process of denationalization of main Peruvian mining companies (Glave & Kuramoto, 2007).

This paper aims to analyze how the economic growth in Peru was affected by the copper industry in the country. First, this paper evaluates 100 years of economic growth and growth in the copper industry with a time series econometric model. Data was collected from different sources such as The World Bank, Central Bank of Peru, and the Ministry of Energy and Mines of Peru. In order to analyze the impact of copper in the overall economy over 100 years, it is important to note that various external variables have affected these growth indicators at different times in the course of this time lapse. However, a simple time series data might tell us about the relationship between copper and GDP growth in Peru. Later, using the same methodology, we will also analyze the impact of the copper industry and the overall Exports of the country. The main goal of this paper is to see the importance that just one material such as copper has had in the economic expansion of Peru, not only in the last few years, but in the course of a century.

For this analysis, various techniques had been used in order to adjust problems that could cause bias in the variables or in the errors. Methods such as Durbin-Wtason statistic or Cochrane-Orcutt estimation has been used to control for stationarity and autoregression respectively. Different models have been used in order to compare the impact and the relevance of each. The models used in the analysis are dynamic, growth-growth, and models with Cochrane-Orcutt transformed variables. Finally, all the results will be analyzed in order to see if there exist statistical significance of evidence of a relationship between the growth in the copper industry either in GDP or overall Exports in Peru.

HEADING 2

LITERATURE REVIEW

Sanborn and Yong (2013) present a discussion paper over the relationship between the expansion in the Peruvian economy over the last decade and the participation of asian countries. Sanborn and Yong highlight three main countries: China, Japan, and South Korea (the three main importers of copper from Peru nowadays). The paper aims to discuss historical events which are relevant on understanding the trading and investment patterns of Peru and Asian countries. The paper emphasizes on one of the main industries of exports, mining. Their final remarks suggest that although Peru's trade with Asia tends to reinforce its position as a mineral exporter, the country has not experienced significant de-industrialization. To the contrary, it has benefited the overall exports as the country has seen an important increase in manufactured products with China than with any other countries.

Irwin and Gallagher (2012) analyze one of the most famous and representative conflict cases of China's investments into Peruvian mining industry. Irwin and Gallagher investigate a single Chinese company Shougang Hierro Peru (one of the main companies operating in mining production in Peru) on how their negative reputation could jeopardize future investment of China in Peru. The authors compare Shougang with other companies such as Yanacocha, Doe Run, and Antamina. They found out that even though Shougang's had unfavorable aspects such as low wages, constant strikes, fines, low percentage of contracted workers, these aspects weren't relatively significant for gaining a much worse reputation than its competitors. However, it was Shougang's bad investment and managerial decisions which end up highly damaging their image. The analysis concludes that the significant bad reputation of Shoungang could have induce to a step back in the constantly increase of Chinese investment in the mining industry of Peru.

Dollar (2017) presents a study on Chinese investment across the world. He analyses mainly Chinese investment into Latin American countries. The paper aims to highlight how investment strategies have been ran in China in the recent years. China became one of the world's largest abroad investors sending huge amounts of capital into countries with poor-governance. Dollar mentions the example of Venezuela, where China invested heavily in the country while going through political instability. But the strategy was not successful as the investment in Venezuela did not seem to be paying off, and so China stop investing in the country. Another example Dollar emphasizes is in the Peruvian mining industry. Dollar examines how developing countries like Peru prefer China's investment instead of other entities such as World Bank or the Inter-American Development Bank. This being because Chinese infrastructural projects rely on the recipient country's own laws and regulations which end up being a much cheaper option than bringing investment from The World Bank which has its own regulations with higher (more expensive) standards.

Glave and Kuramoto (2007) make an analysis of the historical situation of mining activities in Peru. Glave and Kuramoto's analysis starts with a historical summary of the impact of multiple political and economic situation on the mining industry for the past 50 years. Then, the analysis focus on the macroeconomic aspects of the historical changes in mining activities. They get to the conclusion that even though mining has had great benefits on macroeconomic aspects in the past, the effects at a micro level are still not consolidated.

Macroconsult (2012) implement an in-depth research about the mining industry in Peru. They analyze macroeconomic aspects that might have affected the Peruvian economy in the last few years. The research also conducts analysis in the impact on regional districts employment, investment, exports, among other variables.

Del Aguila et al. (2017) summarize the copper industry in Peru. They describe the procedure used from the extraction until the refinement in the production of copper. With data from MINEM, the authors analyze the current situation of the industry at the moment. The paper highlights specific statistics such as Peru being the second biggest producer of copper in the world behind its neighbor country Chile. They also give a brief summary of the four main companies producers of copper (Cerro Verde, Antamina, Las Bambas, and Southern Peru) which together represent about 70% of the total national production bringing a possibility of oligopoly in the industry.

Camacho et al. (2015) implement an analysis in the impact of mining activities in Peru on relevant socio-economic indicators such as production diversification, employment, and agricultural development including gender difference. The research suggests that there is a positive effect of certain mining activities on economic diversification. However, it also has a negative effect on employment in the manufacture industry. The authors indicate that the results suggest that the economic diversification concentrates more in other areas like Services and Commerce. This would have important political consequences to analyze.

Elshkaki et al (2016) conduct a research on the copper market in several countries with data from multiple sources. The authors analyze the copper industry demand and supply drivers as well as estimates of the market up until 2050. The research suggests that copper demand is significantly correlated with GDP per capita. Elshkaki et al also estimate that the demand for copper is going to continue increasing significantly over the next years. It is estimated to increase between 275% and 300% by 2050 and many countries will not be able to sustain their production. This is based on their current share of global copper production.

Landa (2016) conducts a more specific research about the copper industry. Landa conducts an experiment comparing the effect of copper extraction activities on regional cities, where copper extraction is heavily conducted with other all other cities. The main cities of copper extraction being Arequipa, Tacna, Ancash, and Moquegua. The experiment finds out that even though there was improvement in infrastructure in the cities where copper extraction was heavily conducted, it was only in a small magnitude. Landa suggests that this problem has two explanations; a shaky vision of sustainability, and the fact that regionalization in Peru is still very poor.

Loayza and Reguiloni (2016) run a similar experiment aiming to determine whether the increase in mining activities in Peru has benefited the local regions where extraction is intensive. The research discovers a positive average effect where producing regions of minerals have earned larger per-capita consumption than other non-producing districts. However, mining has also had a negative effect as inequality is been higher in producing regions than in non-producing. The authors conclude that the distributional impact might explain the social discontent of locals in the country about mining activities.

HEADING 3

METHODOLOGY

In order to analyze the impact of the production of copper on the growth of the economy, the analysis will conduct different regression analysis using multiple Time Series Models. The variables of the analysis will be the GDP (in millions of dollars), GDP growth, copper production (in thousands of metrics tons), and copper production growth from Peru for the first part of the experiment. The data was recorded since 1917. For the second part of the experiment, the total exports of Peru since 1930 (in millions of dollars) will be regressed with the copper production in order to see the impact that a single material (copper) can have in the total exports of a nation. The experiment can also show if over the course of a 100 years copper has been exported significantly higher than it has been used in the country.

Data for the experiment was collected from The Central Bank of Peru (BCR) and the MINEM. The data on GDP, Exports, and imports, collected from the BCR, are in nominal terms which is controlled by inflation in the multiple models. These variables are measured in millions of dollars. The advantage of using variables in nominal terms is that it allows to use information that is a century old. On the other hand, copper production is measured in thousands fine metric tons (FMT). Data was collected from The Peruvian Ministry of Energy and Mining (MINEM). Copper production data over the past 100 years can be seen in Figure 1.1. It is clear that there is one specific outlier at the beginning of the 1960s where copper production skyrocketed. This might be because of the new Code of Mining in the 1950s which benefitted mining activities for multiple multinational companies (Glave and Kuramoto, 2007). In order to get a more accurate analysis, this unique variable was removed for the experiment. Data after omitting the outlier can be seen in Figure 1.2.

The analysis is divided into two parts that later will be analyzed together in the Results section. For the first part of the analysis, the dependent variables will be GDP, total exports, GDP growth, and total exports growth. The independent variables in the analysis will be copper production and copper production growth. The variables of control will be overall inflation in the country since 1917 and total imports. The experiment will be conducted in different models in order to compare the results and look for statistical significance. Since we are dealing with a Time Series Model, the experiment will test for stationarity and autocorrelation using different statistical techniques and adjusting accordingly to the results. The models in the first part of the experiment are:

Model 1: $GDP_t = \beta_0 + \beta_1 COP_t + \beta_2 INFL_t + \varepsilon_t$

Model 2: $GGDP_t = \beta_0 + \beta_1 GCOP_t + \beta_2 INFL_t + \varepsilon_t$

Model 3: $EXP_t = \beta_0 + \beta_1 COP_t + \beta_2 IMP_t + \beta_3 INFL_t + \varepsilon_t$

Model 4: $GEXP_t = \beta_0 + \beta_1 GCOP_t + \beta_2 GIMP_t + \beta_3 INFL_t + \varepsilon_t$

Model 1 is a simple model analyzing the impact of actual values of copper production (COP) on GDP over time. The control variable inflation (INFL) and the error term at time t. The Betas are the parameters to calculate. Model 2 is a similar model to Model 1, but instead of using actual values, the model analyzes growth values for each of the variables such as growth in GDP (GGDP) and copper production growth (GCOP). Model 3 and 4 follow the same methodology as Models 1 and 2 but instead of GDP being the dependent variable, Model 3 and 4 analyze the impact on the total exports being the dependent variable. The independent variables of analysis are copper production and copper production growth. The control variables are imports (IMP), growth in imports (GIMP), and inflation (INFL). Lastly, the error term at time t.

The second part of the analysis will evaluate slightly different kinds of models. Dynamic models are introduced in this part. Dynamic models are similar to the Models 1 through 4. They have the same variables and methodology (evaluating actual and growth values for the indicated variables). The difference is that Dynamic Models considers the lagged value of the dependent variable as a control variable. The dynamic models are presented as follows:

Dynamic Model 1: $GDP_t = \beta_0 + \beta_1 GDP_{t-1} + \beta_2 COP_t + \beta_3 INFL_t + \varepsilon_t$

Dynamic Model 2: $GGDP_t = \beta_0 + \beta_1 GGDP_{t-1} + \beta_2 GCOP_t + \beta_3 INFL_t + \varepsilon_t$

Dynamic Model 3: $EXP_t = \beta_0 + \beta_1 EXP_{t-1} + \beta_2 COP_t + \beta_3 IMP_t + \beta_4 INFL_t + \varepsilon_t$

Dynamic Model 4: $GEXP_t = \beta_0 + \beta_1 GEXP_{t-1} + \beta_2 GCOP_t + \beta_3 GIMP_t + \beta_4 INFL_t + \varepsilon_t$

All the results of the multiple models will be analyzed later in the paper. The research aims to compare the results of the multiple models in order to look for statistical significance of the impact of copper on GDP and total exports. Also, when dealing with time series data, specific problems may arise when dealing with variables that are stationary or autocorrelated. That’s why in the next section these 2 problems will be tested and assessed if necessary.

HEADING 4

AUTOCORRELATION AND STATIONARITY

First of all, tests were ran in order to see if the times series data in the model was stationary. By following Bailey's (2016) and Andrei & Bugudui (2011) work on stationarity and time series data, we run a test for unit roots in the variables with the Dickey Fuller test where the null hypothesis is y = 1 and alternative hypothesis is y < 1. The following equations show the steps taken to get the results and decide whether the particular variable is stationary:

i) $$\Delta Y_t = \alpha Y_{t-1} + \varepsilon_t$$

ii) $$\Delta Y_t = \alpha Y_{t-1} + \beta_0 + \beta_1 Time + \beta_2 \Delta Y_{t-1} + \varepsilon_t$$

Each change in the variable is regressed with its lagged value, time period (TIME) or years, and the change in the lagged value of the variable. Table 1 shows the results this stationarity test. It can be seen from the model that the variables of GDP, Copper production, and Exports, show no significance of non-stationarity as the t-value in the regression of ii) is not sufficiently negative. On the other hand, the growth of the same variables is stationary as shown in Table 1.

Secondly, we conduct autocorrelation tests which might affect the error terms in the analysis if found in any of the models. By running the regression analysis of the simple models, we can get the residuals for each model and use the error terms of the Models 1 through 4 to run an auxiliary regression to look if there is evidence of autocorrelation in the model. The auxiliary regression runs the error term from each model with the lagged value of the error. The formula goes as follows:

iii) $\hat{\varepsilon}_t = \rho\hat{\varepsilon}_{t-1} + \upsilon_t$

Table 2 shows the results for the tests. We can see that Models 1 and 3 show significance of autocorrelation as its slope value is significantly apart from 0. However, Models 2 and 4, with the growth values, do not show significant evidence of autocorrelation. In order to correct for autocorrelation, a Cochrane-Orcutt estimation is performed following work from Bailey (2016) and Simonoff (2016). The data is transformed into new values (just a computer trick, not significant values) which are displayed in Table 3. In order to see the effect of the transformed values of Model 1, Figures 2.1 and 2.2 show a comparison of the errors of the original models with the transformed models' errors. Figures 2.3 and 2.4 also show visual explanation of the change in the errors from the original variables to transformed variables of Model 3. Only Models 1 and 3 variables were transformed as only these models showed evidence of autocorrelation. The figures show improvement in the autocorrelation of the errors over time. The procedure for transforming the data is shown as follows:

iv) $Y_t = \beta_0 + \sum \beta_i X_{t,i} + \varepsilon_t$

v) $Y_t - \rho Y_{t-1} = \beta_0 - \rho\beta_0 + \beta_i \sum X_{t,i} - \rho X_{t-1,i} + \varepsilon_t - \rho\varepsilon_{t-1}$

vi) $\tilde{Y}_t = Y_t - \rho Y_{t-1}$ $\quad \tilde{X} = X_t - \rho X_{t-1}$ $\quad \tilde{\beta}_0 = \beta_0 - \rho\beta_0$

vii) $\tilde{Y}_t = \tilde{\beta}_0 + \beta_i \tilde{X}_t + \upsilon_t$

The variables in Models 1 and 3 are transformed into new values shown in Table 3. The transformed data is supposed to correct for autocorrelation following the methodology from steps

iv) to vii). The transformed data also transforms the models which will be called Transformed Model 1 and Transformed Model 3 as shown in Table 4.

HEADING 5

RESULTS

The Tables 4 and 5 show the results for all the models analyzed. For Table 4, the Transformed Models (corrected by autocorrelation) actually show statistical significance of the impact of copper on GDP and total exports. The model suggests a very high coefficient of copper production. This could be interpreted as: for every 1,000 Tons of increase in the production of copper, would lead to an increase in GDP of 69 million dollars. This particular statistic looks immensely high. Thus, we need to be careful when analyzing this data as many control variables were not considered for the simplicity of the research. It is important to take these results as an example of a possible relationship between variables and not an exact approximation.

Transformed model 3 and Model 4 also statistical significance of an impact of copper production on Exports. Even though results are modest, both Models 4 and Transformed 3 show statistical significance at the 0.1 level in Model 4 and 0.01 in Transformed model 3. The adjusted R-squared is 0.9 and 0.4 for Model 4 and Transformed Model 3 respectively. Unlike exports, GDP shows different results. Transformed model 1 shows statistical significance at the 0.01 level. However, Model 2 does not show any statistical significance in the results. That's why is important to be rigorous when analyzing these results.

The results from the dynamic models are presented in Table 5. The experiment finds statistical significance of a relationship for copper growth on Dynamic Model 1 at a 0.05 level. Unlike Model 1, Dynamic Model 1 coefficient is much lower. This could represent a strong relationship between the actual and lagged value of the variables since the Dynamic Models control for lagged values. Similarly, to the first part of the analysis, Dynamic Model 2, which includes growth variables, do not show statistical significance for GDP. Dynamic model 3 shows statistical significance of a relationship of the variables of analysis at a 0.01 level. The results are close the the ones found in Model 3 but with a lower significance level. The coefficient value is lower, which indicates a relationship between actual and lagged values for total exports as well. Unlike, Model 4, Dynamic Model 4 does not show statistical significance in the results.

The multiple models analyzed in this paper show multiple results with multiple interpretations. However, we can analyze each model considering their own characteristics. The transformed models 1 and 3, show strong statistical significance in the results. Both models are corrected for autocorrelation. Hence, their errors are more reliable. Dynamic models give relatively lower results but also significant. It is possible to argue that the lagged values of the variables of analysis play a very important role. The models with growth variables (Model 2, Dynamic Model 2, and Dynamic Model 4) do not show statistical significance of the results which leads us to think that the growth in the variables are determined likely at random. The only model (Model 4) shows statistical significance at a 0.01 level. This shows that growth in Exports can be caused by the increase in production of copper.

HEADING 6

CONCLUSIONS

Many studies suggest that the recent economic expansion in Peru has occurred as a result of the increasing production in mining activities. Peru in the last decade has taken advantage of the increasing investment flow specially in the mining industry coming into the country. Peru has also benefitted from their large reserves of metals such as copper. According to data from MINEM, Peru is the third country in the world with the most reserves of copper behind Chile and Australia. Peru has also exploited other metals like silver or gold being the first and seventh with more reserves in the world.

It is evident that the copper industry is going to continue increasing over the next few years as China's investment continues to increase in Peru. According to Diario Gestion, Chinalco (one of the biggest Chinese mining companies in Peru) has already started an investment of extraction in Tomorocho (one of the largest reserves of minerals in the country) and is projected to invest around 2 billion dollars every year increasing copper extraction in about 45 percent by 2020.

The studies found by Landa (2016), and Loayza & Reguiloni (2016) show evidence of regional impacts of the increasing production of copper. On the other hand, studies by Glave & Kuramoto (2007) and Macroconsult (2012) aim to analyze macroeconomic effects. The simplicity of the models in this research paper, allowed us to gather and analyze data since 1917. It is clear that the Peruvian economy did not solely depend on the production of copper for 100 years, but it is one determinant variable. The analysis showed significant values to conclude that copper indeed was influential in the Peruvian economy. One of the most representative and important variables in the Peruvian economy is Exports. In the analysis we found that exports over the course of 100 years, has been heavily dependent on one specific material, copper. Although the analysis shows different results with multiple interpretations, it is clear to see that the production of copper was very important in the Peruvian economy. However, these results must be taken with prudence due to the simplicity of the model. The models aimed to discover a relationship between the variables of analysis. A much deeper and complex study is needed to discover significant results for this analysis. However, the paper found evidence of a relationship between GDP, Exports, and copper production over time which could be helpful for major studies.

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FIGURES

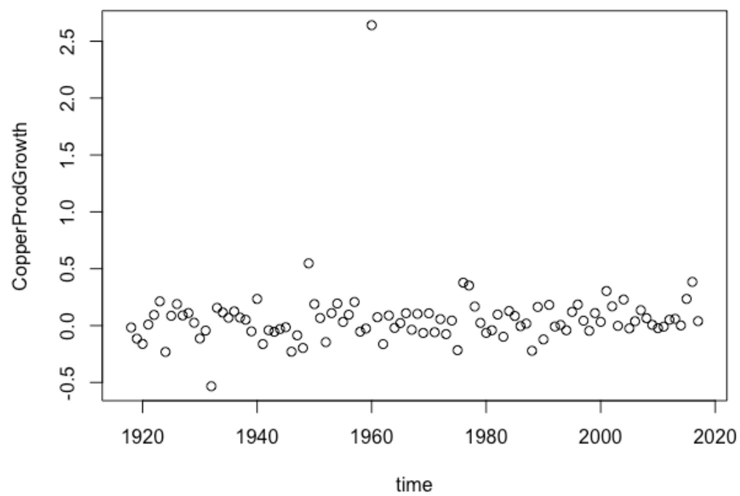

Figure 1.1 - Outlier

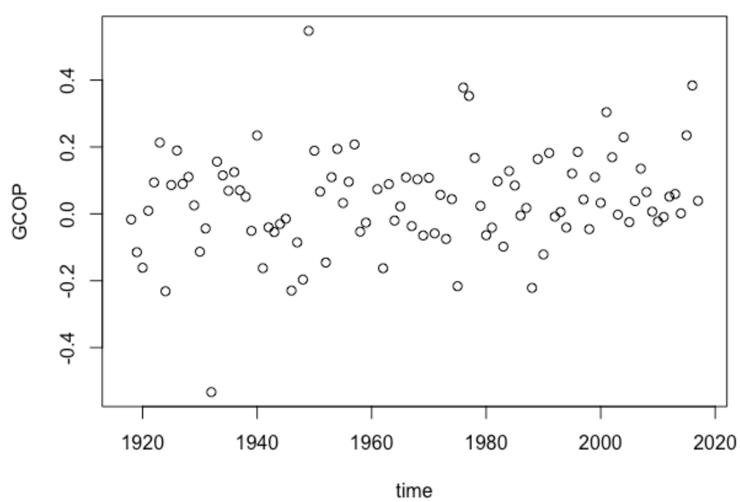

Figure 1.2 - Outlier correction

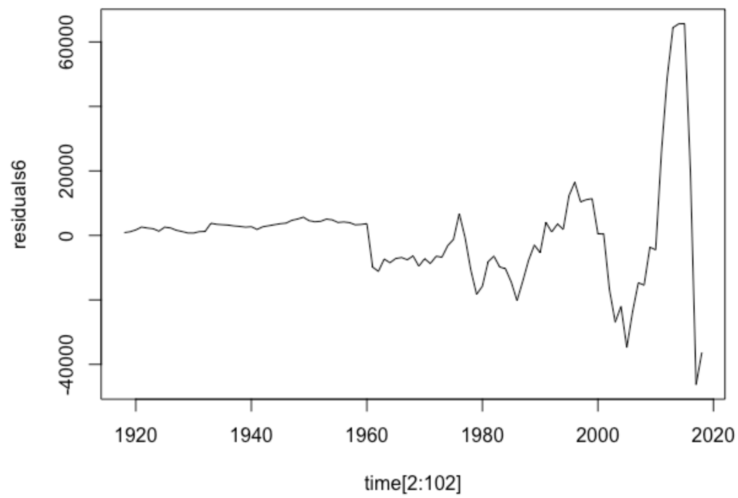

Figure 2.1 - Model I errors over time

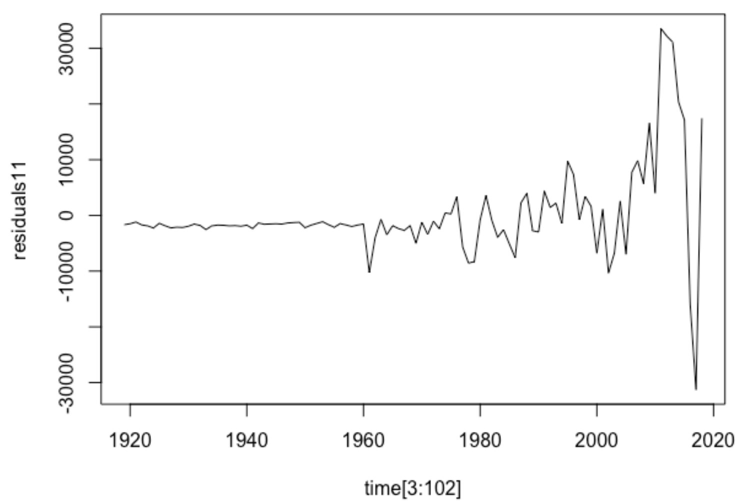

Figure 2.2 - Model I errors corrected

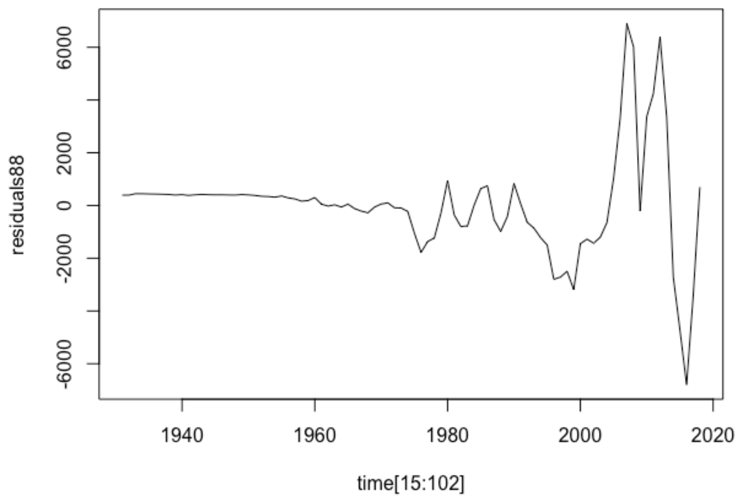

Figure 2.3 - Model 3 errors over time

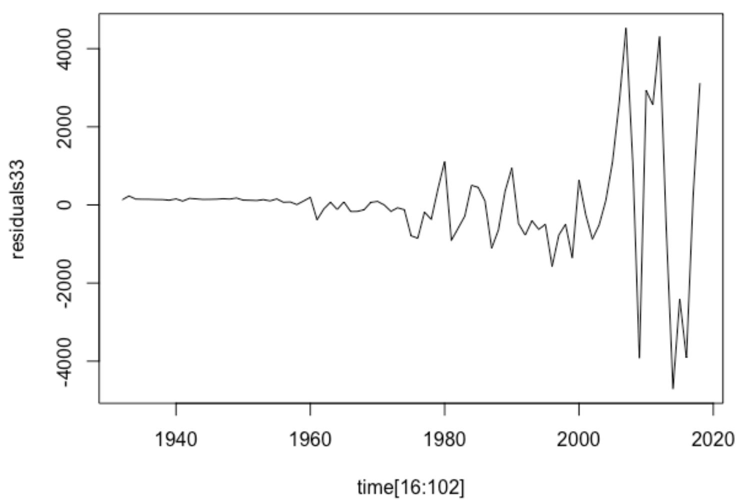

Figure 2.4 - Model 3 errors corrected

TABLES

Table 1

Stationarity Dickey-Fuller Test

		GDP	Copper	GDP growth	Copper Growth	Exports	Exports Growth
Lagged Value	*Beta*	0.02114	0.08660	-0.9117541	-1.0193275	-0.01379	-1.00185686
	SD	0.01452	0.03649	0.1307339	0.1501085	0.02666	0.12789410
	t-value	**1.455**	**2.373**	**-6.974**	**-6.791**	**-0.517**	**-7.833**
Time	*Beta*	31.90145	-0.09448	0.0006539	0.0008804	21.92989	-0.00005462
	SD	24.12636	0.46620	0.0005157	0.0005509	12.48111	0.00063796
	t-value	1.32	-0.203	1.268	1.598	1.757	-0.086
Lagged Change of Value	*Beta*	0.40494	0.08500	0.1129013	-0.0046880	0.41022	0.17311602
	SD	0.10094	0.12427	0.1011307	0.1061633	0.11005	0.09995953
	t-value	4.012	0.684	1.116	-0.044	3.728	1.732
Intercept	*Beta*	-62048.93831	178.28772	-1.2234575	-1.6895920	-42864.099	0.18919192
	SD	47179.20406	908.35398	1.0136090	1.0833671	24522.2024	1.25949333
	t-value	-1.315	0.196	-1.207	-1.560	-1.748	0.150
N		95	95	94	91	86	84
R^2		0.3669	0.2264	0.3988	0.5018	0.1849	0.4609
Diagnostic		**Non-Stationary**	**Non-Stationary**	**Stationary**	**Stationary**	**Non-Stationary**	**Stationary**

Table 2

Serial Correlation Durbin-Watson error method

		Model 1	Model 2	Model 3	Model 4
LagError	***Beta***	**0.82767**	**0.184720**	**0.72624**	**0.090518**
	SD	0.06108	0.098911	0.07464	0.108393
	t-value	13.551	1.868	9.729	0.835
Intercept	***Beta***	-308.68707	-0.002324	1.31174	0.002274
	SD	989.72428	0.014037	144.67385	0.013102
	t-value	-0.312	-0.166	0.009	0.174
N		99	97	86	84
R^2		0.6485	0.02501	0.5213	-0.003616
Diagnostic		**Autocorrelation**	**No Autocorrelation**	**Autocorrelation**	**No Autocorrelation**

Table 3

P-transformation Cochrane-Orcutt model

	GDP	Copper	GDP growth	Copper growth	Inflation	TR Copper	TRGDP	TR Inflation
1919	760.500	39.320	-0.014	-0.115	0.146	2.560	122.201	0.018
1920	913.500	32.981	0.201	-0.161	0.117	0.437	284.057	-0.004
1921	612.600	33.284	-0.329	0.009	-0.052	5.987	143.477	-0.149
...								
2015	192353.09	1700.817	-0.053	0.235	0.035	560.584	24244.986	0.009
2016	194947.26	2353.859	0.013	0.384	0.036	946.143	35742.374	0.007
2017	214709.90	2445.585	0.101	0.039	0.028	497.367	53357.902	-0.002
	Original Values					Transformed Values		

Table 4

Models 1 through 4

		TR model 1	Model 2	TR model 3	Model 4
Intercept	Beta	1445.237	0.066469***	-181.14632	0.0277627
	SD	997.154	0.015263	177.45568	0.014814
	t-value	1.449	4.355	-1.021	1.874
Copper	Beta	**69.321*****		**4.13641*****	
	SD	6.222		1.14839	
	t-value	11.141		3.602	
Copper growth	Beta		**0.006155**		**0.1963544***
	SD		0.098436		0.0892350
	t-value		0.063		2.200
Imports	Beta			0.91746***	0.45847***
	SD			0.05562	0.0630666
	t-value			16.495	7.270
Inflation	Beta	28.986	0.001145	7.81334	-0.0005476
	SD	106.315	0.001779	17.40420	0.0015268
	t-value	0.273	0.644	0.449	-0.359
N		99	98	86	85
R^2		0.5524	-0.01644	0.9049	0.3963

Table 5

Dynamic Models

		Dmodel 1	Dmodel 2	Dmodel 3	Dmodel 4
Intercept	Beta	-381.29861	0.049415**	-395.9186	0.0361771
	SD	632.44281	0.016774	276.3654	0.0107203
	t-value	-0.603	2.946	-1.433	3.375
Lagged Value	Beta	0.98391***	0.196741*	0.4254**	-0.0013191
	SD	0.02961	0.098883	0.1294	0.0660150
	t-value	33.225	1.990	3.287	-0.020
Copper	Beta	**8.10866****		**2.6131***	
	SD	3.06094		0.9963	
	t-value	2.649		2.623	
Copper growth	Beta		**0.028842**		**-0.0204152**
	SD		0.096937		0.0601541
	t-value		0.298		-0.339
Imports	Beta			0.5511***	0.5296167
	SD			0.1482	0.0452773
	t-value			3.719	11.697
Inflation	Beta	19.89879	0.001285	-1.8270	0.0008588
	SD	58.90552	0.001744	23.2377	0.0010253
	t-value	0.338	0.736	-0.079	0.838
N		99	97	86	84
R^2		0.9921	0.01452	0.9778	0.6434

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