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Estimating the function of copper consumption in Iran between 1991- 2011 using Johansen model

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Abstract

This study aims to estimate the function of copper consumption using the Johansen approach in time series data, between 1991-2011 in Iran. The literature review of specialized consumption and demand functions shows factors influencing the consumption of copper including copper price variables, aluminum price as a substitute commodity, oil price as a complementary commodity, and industrialization intensity. For this purpose, raw data from the World Bank and International Copper Study Group, were used to extract the initial data needed for the current study, and then research variables were calculated and applied in a seasonal manner. In the next stage, using vector autoregressive, Johansen cointegration test, and vector error correction model, the existence of long-run cointegrated equilibrium relationship was surveyed by vector error correction model. Model estimation results show that there is a positive correlation between between industrialization intensity variable and the price of substitute product (Aluminum) and copper consumption ratio Moreover, there was a significant negative correlation between copper prices and complementary commodity price (Oil), during the review period in Iran. It should be noted that aluminum and copper prices can impact the copper consumption, and an awareness of this can influence making copper sales contracts domestically and abroad.

Keywords: *Consumption, Price, Copper, Aluminum, Oil, Industrialization Intensity, Johansen Model.*

1. Introduction

Copper is the third metal consumed after steel and aluminum in the world. The unique properties of this metal, has provide the widespread use of copper and its alloys in various industries such as construction, automotive, electrical, military and so on. Thus in less than a century, its consumption has increased twenty times more [1].

Reviewing the function of copper consumption in Iran is important because Iran among the world countries with copper reserves, is in good standing. Parts of the country in terms of mineral resources, are located on the world copper belt from the northwest area to southeastern Iran and Azerbaijan. From 35 billion tons of copper ore in the world, about 11 percent is related to Iran, and this object can have a huge impact on the growth of the country's industrial output and exports [2].

Theoretical studies indicate that variables such as the price of copper [3], aluminum price as substitute commodity [3], Oil price as complementary commodity [4] and industrialized intensity [5], are the most important factors affecting the copper consumption. On the other hand, reviewing internal studies show that a study that examined the factors influencing the consumption of copper in Iran, has not been conducted. Hence, due to the importance of the issue and the lack of similar studies, the need for such articles is obvious. To this end, the main goal of this paper, is to identify the factors affecting the consumption of copper with time series econometric techniques. Important questions that this paper seeks to answer are the followings:

- Is there andy correlation between the copper price variable and copper consumption?
- Is there any correlation between factors affecting the consumption of copper such as

prices of substitutes and complements, the intensity of industrialization, and copper consumption?

In line with the foregoing question, the study aims at testing the following hypotheses:

- There is a negative correlation between the price of copper and copper consumption.
- There is a positive correlation between substitute commodity prices such as aluminum, increase and copper consumption.
- There is a negative correlation between complementary commodity price, like oil, elevated and copper consumption.
- There is a positive correlation between the intensity of industrialization and consumption of copper.

To this end, raw data were extracted from the World Bank and International copper study group databases during 1991-2011. Through programming,, the required variables will be and will be used in estimating econometric models. Econometric model used in time-series data will be estimated using Johanen's (year) approach.

2. Theoretical framework and literature review

The consumption theory started systematically with the John Maynard Keynes "General Theory" book, which was published in 1936. In Keynes's theory of economic fluctuations, the consumption function was located at the center and then, in the analysis of macroeconomic, consumption function, has played a decisive role. Keynes believed that several factors influence consumer decisions, but in the short term, the most significant item is income [6].

Based on the theoretical discussion of demand, the overall demand function is as follows:

$$Q_x = f\,(P_x, P_y, I, \mathrm{W}, \mathrm{X}) \qquad (1)$$

In equation 1, Q_x is the demand for the product or service desired, P_x, price of the commodity or service, P_y, alternative commodity prices, and the variables I, X and W can represent other variables such as complementary commodity prices, population, expectations of future income, which according to various consumption functions, these factors can change.

Therefore, to extract the copper consumption function, factors affecting the demand function factors such as the growth of industries such as the telecommunications industry, electrical and electronic industry with copper as the main inputs, which are expected to have an indirect effect on copper demand, were taken into account. The price of substitutes is also expected to have a direct impact on copper demand [7].

It is noteworthy that currently, optical cable, and aluminum are considered as substitutes of copper due to the excellent optical cable transmission and lightweight aluminum metal. However, the high price of copper, especially is effective in their substitution [8].

Scholars from the far past believed that metals demand is associated with economic growth and is impressive in some levels, such as construction, transportation, construction and industrial equipment. The use of metal even is an indicator of a country's industrial development. More recently, researchers have focused on the decline in metal demand growth in OECD economies after 1973, despite the continuing growth of industrial activity. Consequently, several researchers believe that the only factor in the growth in metals demand is not the increased intensity of economy in the futures markets. The difference between traditional and modern views show the effectof industrialization as an explanatory variable for metals demand over time. Industrialization intensity is defined as in equation 2:

$$IND_t = \frac{D_t}{GDP_t} \qquad (2)$$

where, IND_t , is the industrialization intensity, D_t , is the total value of industrial goods produced and GDP_t Is the gross domestic product in period t. Several studies have shown that the intensity of the Copper has a U- shaped relationship with GDP (Figure 1) [9].

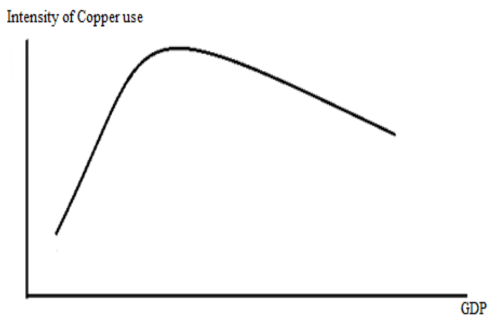

Figure 1. Relationship between intensity of copper use and GDP.

What follows reviews previous studies related to the estimation of demand and consumption functions of commodities and services will be discussed:

Ibrahim and Hurst (1989) studied the factors affecting energy and oil demand in thirty developed countries in the 70s and 80s, using cointegration functions model. The variables studied in this research are energy prices and national income. The results indicate a strong relationship between income and total energy demand and oil. But the price elasticity of energy demand in the short-term and long-term, low has been reported [4].

Vial (1989) reviewed the factors affecting copper consumption fluctuations in the years between 1965 and 1987 in the United States of America. Vial considers copper consumption as a function of the index of industrial production, the price of copper, the price of substitutes and price of energy. The results indicate that copper consumption, correlate directly with the industrial production index and the price of substitutes, and correlated inversely with the price of copper and energy prices [10].

Deviatov and Wallance (2006) use the Kagan model to estimate the world demand function for gold between the years 1561 and 1913. The variables studied in this research, are the price of gold and gold production index. Estimates show that gold consumption correlate inversely with gold prices, and directly correlates with gold production index [11].

Mark Evans and Andrew C. Lewis (2004) in a study entitled "dynamic model of metals demand" reviewed the history of the various metals demand functions. Accordingly, Bozdogan and Hartmann (1979), assume that copper demand is a function of copper prices, the price of substitute commodity and GDP. In another study Ferretti and Gilbert (2001) using time series, estimate the consumption of copper, zinc and tin as a function of technological change, changes in industrial production, changes in real prices and price volatility. Evans and Lewis concluded that each metal has its own demand curve in the short term, but in the long term, the demand curve is similar for most metals [12].

Halada et al (2008) sought to estimate the consumption of metals such as gold, silver, iron, aluminum, copper, lead, zinc, nickel and so on for 2050. The forecasts are based on the linear decoupling model of the relation between per capita metal consumption and per capita GDP. The models of each metal are applied to the economic development model of the BRICs and G6 countries. According to these forecasts, the overall consumption of metals in 2050 will be five times greater than the current levels, and demand for metals, such as Au, Ag, Cu, Ni, Sn, Zn, Pb and Sb, is expected to be several times greater than the amount of their respective reserves. Demand for Fe and Pt, which is considered to be optimistic about the resource exhaustion, will also exceed the current reserves. Urgent measures are needed to find alternatives from common resources and to shift into sound materials circulation society [13].

Vishal Chandr Jaunky (2013) examines the copper consumption-economic growth nexus for 16 rich economies through the panel data model for the period 1966 to 2010. Various generations of panel unit root and cointegration tests are applied. Both series are found to be integrated of order one. Evidence of cointegration is found especially when controlling for breaks and long-run cross-sectional dependence. Causality is investigated using a vector error-correction mechanism (VECM) framework. At the individual level, unidirectional causality running from economic growth in copper consumption is unraveled for Finland, France and UK in the long-run. Unidirectional causality is also found running from copper consumption to economic growth in Spain. Long-run bi-directionality between economic growth and copper consumption is found in Belgium, Greece, Italy, Japan and South Korea. The neutrality hypothesis holds for Australia, Austria, Canada, Netherlands, Portugal, Sweden and USA in the long-run. Taken as a whole, panel causality test reveals a long-run unidirectional causality running from economic growth to copper consumption [14].

What follows discusses internal studies. But since there is no study which investigates factors affecting copper consumption or other metals in Iran, in this part of the study, the estimation of the consumption function of other commodities and services will be reviewed. Safavi (2001) in his study has provided the demand function of the protein products which are divided into urban and rural areas, by combining time-series and cross-sectional data using data from the years through 1971-1999. The variables studied in this research are protein price and income of the population. The results indicate that the income elasticity of meat items is higher than non-meat items (eggs and dairy) in urban and rural areas and also by price elasticity, consumption of red meat can be reduced [15].

Farzin and Golelale (2008) sought to estimate the demand function of tourism, and the price and income elasticities of tourism demand in Iran. According to the statistics of Tourism Authority, Iran's tourism demand function from five

developed coutries was estimated by a regression model for the period 1969-2006. The independent variables in this study are the consumer price index, destination countries' average GDP, real exchange rate, the sum of exports and imports of non-oil trade volume between Iran and the countries which have the advantage of tourism; dummy variable for war, and a number incoming tourists to Iran as the dependent variable are presented. The results demonstrate that Iran's foreign tourism demand is less sensitive to changes in prices and therefore demand for foreign tourism in the long run, has price elasticity [16].
Changi Ashtiani and Jellouli (2013) estimated the long-term and short-term relationships of the electrical energy demand model of Iran, using the cointegration of time series data and econometric techniques, especially Auto Regression Distributed Lag (ARDL) and Error Correction Mechanism (ECM). In this study Iran's electricity demand was considered a function of electricity prices and energy prices. Based on the results, it was confirmed that electricity demand is inelastic with respect to its price [17].
Internal and external review of previous studies show that a study that examines the factors affecting copper consumption using the Johansen approach in time serieshas not been done yet. Hence, compared to other studies in this area in Iran the current study is distinct.

3. Introduction of estimation model

To identify and explain the long term relationship between variables, several approaches have been proposed. Engel - Granger method, ARDL method and famous Johansen- Juselius method, is an example of these techniques. Initially, Engel- Granger method was introduced, but due to the lack of consideration of short-term dynamic interactions between the variables, was not valid [2], because the estimates are biased and therefore, hypothesis testing using common test datawill be void.
For this reason, we should consider using the methods that includeshort-term dynamic patterns and lead to more accurate estimates of the model coefficients. ARDL model, was an alternative model that was introduced, but may between several time series variables, over a long term cointegration vector exist. By formulating a method for cointegration vector which is used in determining the vector cointegration Johansen- Juseliussolved these defects and offered a test for determining the long term number of vectors that specify the short term equation.
This study aims to obtain time series copper consumption model in Iran; To estimate the long-term and short-term correlation between the variables of the model, Johansen-Juselius cointegration model and vector error correction model was used.
Autoregressive Vector equation, VAR (p), is as follows:

$$Xt = \sum_{i=1}^{p} \Phi i Xt - i + \varepsilon t \quad (3)$$

About 2, Xt represents a vector containing variables, Φi coefficient matrices and εt is a residual element. According to Granger theorem, for each model of VAR (p), Equation 3 can be defined as a vector error correction model [13].

$$\Delta Xt = \Pi Xt - 1 + \sum_{i=1}^{p-1} \Gamma i \, \Delta Xt - i + \varepsilon t \quad (4)$$

where the matrices Γ and Π, respectively show short term and long term relationships among the variables of the model. Assuming that the matrix Π has rank r, the matrix Π can be decomposed into equation 4 [18].

$$\Pi = \alpha \beta^{'} \quad (5)$$

About 4, α is short term relationship adjustment matrices to long term with dimensions P × r and β is the convergence vector between variables with dimensions P × r. Johansen pattern provides maximum likelihood estimates of α and β. Also Trace and Maximum eigenvalue tests are used to determine the matrix rank of Π and achieve convergence relations (r). To use Johansen technique, first must calculate the optimal number of endogenous variables. Therefore, using the values of variable level, VAR model is formed and its rank, using Akaike criteria (AIC) and Schwarz (SBC) can be determined. Then, using the Trace and Maximum eigenvalue tests ,the number of cointegration vectors is determined [19].

4. Model estimation

The aim of this study is to investigate the factors affecting copper consumption in Iran. Therefore, variables in the model will be used seasonally during the years 1991 to 2011. The procedure is as the first step, unit root test of individual variables is examined (Table 1). Then the autoregressive model estimation is taken. Derivation of optimal lags value of variables is done as follows (Table 2). In the next step, integration testing is done to indicate that there is a long term relationship between the variables in the model (Tables 3, 4) and then the vector error correction model will be estimated. Finally, the model results will be interpreted[1].

Then, econometric model, considering the general model for estimation of consumption function used in the Vial article [10], is explained as follows:

$$L(CU_c)_t = \alpha_0 + \alpha_1 L(CU_p)_t + \alpha_2 L(AL_p)_t + \alpha_3 L(\mathrm{OIL}_p)_t + \alpha_4 L(IND)_t + U_t \quad (6)$$

In equation 5, CUc is copper consumption, CUp is copper prices, ALp is aluminum prices, IND is the industrialization intensity (that is, from the division of manufactured goods produced in the GDP), OILp is oil price and Ut is a residual term.

4.1. Results of unit root test

The stationary test, is an important requirement for economic equations with time series data. There are several approaches in identifying the stationary series of unstationary ones, but the most important methods are Dickey- Fuller, Augmented Dickey-Fuller and Phillips-Perron test.

According to what was mentioned to check the validity of the proposed model variables, Phillips Perron test will be discussed. The null hypothesis, that there is a unit root in time series variables is investigated according to MacKinnon test in Table 1.

4.2. Determination of the estimation model

The results of the stationary test showed that all variables got stationary in first difference. To this end it is necessary to cointegration of the variables to be investigated. Variables are examined using a Johansen cointegration test which is required before this test, the optimal lag of variables be determined using VAR models outcome. To determine the optimal lag in the model, results reported in Table 2 show that based on Monte- Carlo, because the number of data is less than 100, Schwarz criterion is the best criterion, and based on this theory, the optimal lag, is 2 in this model. The input parameters of the model, are the price of copper, aluminum prices, oil prices and industrialization intensity in Iran, from 1991 to 2011 that based on these variables, the Iran`s consumption of copper in this period will be estimated.

Based on the Johansen cointegration model and with considering the trace and maximum eigenvalue test, the existence of a cointegration vector of this model is demonstrated (Tables 3, 4). According to Table 1, because all the variables measured got stationary in first difference level, so the best way to estimate the long term relationship, is Johansen model, that the results of the model are as follows:

$$L(CU_c) = 37.327 - 1.505 L(\mathrm{CU_p}) + 7.469 L(AL_p) + 33.881(\mathrm{IND}) - 1.71 L(OIL_p) \quad (7)$$

The results of model 6 shows that all the coefficients of the variables have the expected signs as theoretical studies. To validate the model, data related to independent variables for the years 2012 and 2013 are placed in model 6, and the response obtained compared to their true values. Accordingly, the amount of copper consumption for the years 2012 and 2013, respectively 131.3 and 133.7 thousand tons are obtained compared with the actual values of the 139.4 and 144.3 thousand tons, not much difference.

The results of the model indicate that: the copper consumption elasticity against copper price is equal to -1.15. Accordingly, one percent increase in copper prices, leads to 1.5 percent reduction of copper consumption in Iran. Consumption elasticity against aluminium prices is equal to 7.47 which indicates that a one percent increase in the price of aluminum, the country's copper consumption, a 7.47 % increase. And since this number is larger than one, also confirm the hypothesis of substitution the copper with aluminum. Consumption elasticity against industrialized intensity is 33.88. Accordingly, with a one percent increase in the intensity of industrialization, country's copper consumption, 33.88% will increase. Consumption elasticity against oil price is -1.71, which implies that a one percent increase in oil prices, leads to 1.71% reduction in copper consumption in the country and the negative coefficient of this variable indicates that oil and copper are complementary commodities.

Continue, to study the dynamic behavior of the variables in the short term and showing speed of adjustment towards long term equilibrium among the variables of the model, the model is estimated using a vector error correction model.

[1]- Softwares used in the study, are Eviews 8 and Excel. Analysis method of information is quantitative.

$$LCUc = 0.18D\left(LCUc\left(-1\right)\right) - 0.049D\left(LCUc\left(-2\right)\right) - 0.31D\left(LCUp\left(-1\right)\right) - 0.09D\left(LCUp\left(-2\right)\right) + 0.76D\left(LIND\left(-1\right)\right) - 2.98D\left(LIND\left(-2\right)\right) + 0.003D\left(LOILp\left(-1\right)\right) + 0.06D\left(OILp\left(-2\right)\right) + 0.32\,D\left(LALp\left(-1\right)\right) + 0.14D\left(LALp\left(-2\right)\right). \quad (8)$$

Results from equation 8 indicate that the variables get close to long term equilibrium with speed 0.040308 and the t-statistic related to the vector error correction model is equal to -3.34, which is statistically significant and the R-squared value of this estimation is 0.73 which indicates that the data fit a statistical model well.

Table 1. Unit root tests.

Variable	**Test Statistic in level**	**Test Statistic in 1st difference**	**Critical values**			**Stationary level**
			1%	**5%***	**10%**	
L (CUc)	-6.20	-2.43	-4.07	-3.46	-3.16	I (1) **
L (CUp)	-4.83	-1.49	-4.07	-3.46	-3.16	I (1)
L (ALp)	-5.06	-2.82	-4.07	-3.46	-3.16	I (1)
L (IND)	-4.11	-2.43	-4.11	-3.48	-3.17	I (1)
L (OILp)	-5.19	-2.43	-4.07	-3.46	-3.16	I (1)

*The criteria used in this study is a 5% probability level.
I (1) ** indicate that the variables get stationary with first difference.

Table 2. Determining the optimal lag using Schwarz criterion.

Number of lag(s)	**Schwarz criterion**
0	-10.67
1	-22.82
2	-23.19
3	-22.04
4	-20.75

Table 3. Unrestricted Cointegration Rank Test (Trace).

Number of cointegrating equation (s)	**Trace**	**Critical value**	**P-value**
None	96.10	76.97	0.0009

Table 4. Unrestricted Cointegration Rank Test (Maximum Eigenvalue).

Number of cointegrating equation (s)	**Maximum Eigenvalue**	**Critical value**	**P-value**
None	42.34	34.81	0.0053
At most one	29.75	28.59	0.0354

5. Conclusions

The main objective of this study is to estimate the factors that influence the consumption of copper in Iran using the Johansen model in time series. For this purpose, after the expression of the theoretical framework, empirical studies are reviewed that these studies suggests that factors such as the price of copper [3], the substitute commodity price [3], the price of copper complementary commodities [10] and degree of industrialization [5] are the most important factors that influence the consumption of copper. Having calculated the correlation between variables, it is observed that:

- there is a negative correlation between the price of copper and copper consumption [3],
- the price of aluminum as a substitute product has a positvie effect on the consumption of copper [3], oil prices as well as complementaries [10]
- the price of aluminum as a substitute product has a negative impact on consumption of copper and finally the industrialization intensity variable that has a positive effect on consumption of copper [5].

The results show that there is a positive correlation between the copper consumption and oil prices. It is expected that an increase in oil prices will involve a decrease in copper consumption. Therefore, it should be noted that changes in oil prices on world marketsaffect the use and application of copper. This could be important in copper sales contracts to domestic and foreign customers.

On the other hand, given that there is a direct relationship between the price of aluminum and copper consumption, similar changes in aluminum prices and copper consumption will occur in the regulation of long term copper contracts.

Although this study aimed to take into account all the factors affecting the copper industry, taking time constaint and sufficiency of data into account, some factors were ignored.; And given that data were available for a few years, so it is recommended in further studies, investigate the impact of other variables such as optic cable as a substitution of copper in the estimation of copper consumption function. And as well as the development of information systems, more data will be available and so on more precise estimates will be occurred for the consumption of copper. It is also suggested to study the consumption function of other metals particularly strategic metals.

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تخمین تابع مصرف مس در ایران طی سال‌های ۱۳۹۰-۱۳۷۰ با استفاده از رویکرد یوهانسن

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چکیده:

هدف اصلی این مطالعه تخمین تابع مصرف مس در ایران طی سال‌های ۱۳۹۰-۱۳۷۰ با استفاده از رویکرد یوهانسن در داده‌های سری زمانی است. بررسی متون تخصصی توابع مصرف و تقاضا نشان می‌دهد که عوامل مؤثر بر مصرف مس شامل متغیرهای قیمت مس، قیمت آلومینیوم به‌عنوان جایگزین، قیمت نفت به‌عنوان کالای مکمل و شدت صنعتی شدن هستند. برای این منظور از داده‌های خام بانک جهانی و انجمن بین‌المللی مطالعات مس، جهت استخراج اطلاعات اولیه موردنیاز در تحقیق حاضر استفاده و متغیرهای تحقیق به‌صورت فصلی محاسبه‌شده و مورد بهره‌برداری قرار گرفته‌اند. در مرحله بعد با به‌کارگیری الگوی خود بازگشت (خود رگرسیون) برداری و تعیین وقفه بهینه و پس از انجام آزمون هم انباشتگی یوهانسن، به بررسی وجود رابطه تعادلی بلندمدت هم انباشته با استفاده از مدل الگوی تصحیح خطای برداری پرداخته‌شده است. نتایج تخمین مدل نشان می‌دهد که رابطه بین متغیرهای شدت صنعتی شدن و قیمت کالای جایگزین (آلومینیوم)، با مصرف مس، مستقیم و معنی‌دار و همچنین رابطه بین متغیرهای قیمت مس و قیمت کالای مکمل (نفت)، با مصرف مس، طی دوره مورد بررسی در ایران، منفی و معنی‌دار بوده است. ازجمله مهم‌ترین نتایج کاربردی مقاله جاری باید به این نکته اشاره داشت که تحولات قیمت نفت و آلومینیوم بر مصرف مس اثرگذار می‌باشند و دانستن این نکته و جهت اثرگذاری می‌تواند در تنظیم قراردادهای فروش مس در داخل و خارج، موردتوجه تولیدکنندگان مس در ایران قرار گیرد.

کلمات کلیدی: مصرف، قیمت، مس، آلومینیوم، نفت، شدت صنعتی شدن، مدل یوهانسن.