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A cointegration and causality analysis of copper consumption and economic growth in rich countries

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ABSTRACT

The paper examines the copper consumption-economic growth nexus for 16 rich economies from 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 individual level, unidirectional causality running from economic growth to 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 for Spain. Long-run bi-directionality between economic growth and copper consumption is found for 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.

Introduction

Copper is one of the oldest metals to have ever been exploited and is still a key input in many sectors such as in power, building, transport and many other sectors. For instance, given its malleability, electricity conductivity and corrosion-resistant capacity, copper is used in generators and cables to provide electricity. It is also utilized during construction of buildings for roofing, cladding, etc. and in the manufacturing of vehicles. These are essentially the products of rich countries and as such copper is closely connected to the economic development of a nation. Following Hricik (1988), while developed nations consume proportionally more copper than developing one, their demand has eventually leveled off. This is because there is a limit to the number of motor cars, washing machines, television sets and other equipment which a family can use.

According to the International Copper Study Group (2013), the copper market is expected to have a production surplus and this may of course affect the price of copper. But then again, this will affect copper consumption and potentially the economic growth of a country. It remains therefore necessary for policymakers to understand the causal link between copper consumption and economic growth in order manage their copper inventories and to meet their objectives of sustaining economic development. They can eventually use such information to make forecasts and enact mineral policies. So far, the literature has focused on time-series studies mainly and very few studies have been done for a group of countries. This paper presents a study of the link between copper consumption and economic growth using panel data from 16 rich countries[2] from the period of 1966–2010. Refined copper consumption data are obtained from the World Metal Statistics (various years) which are compiled from the World Bureau of Metal Statistics (2012) and those of real gross domestic product (GDP) are compiled from the World Development Indicators CD-ROM (2011).

The remainder of this paper is organized as follows: Section 2 reviews the existing literature. Section 3 discusses the testing framework. Section 4 presents the results. Section 5 concludes and provides some the policy implications.

Review of literature

The literature on the link between metal consumption and economic growth is somewhat scanty. Tilton (1989) investigates the consumption trend of six industrial metals in the OECD, USA,

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[2] The time frame and the selection of countries are purely dictated by the availability of data. The rich economies follow the classification of the World Bank (at http://go.worldbank.org/K2CKM78CC0).

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Japan and the EEC over two periods, 1960–1973 and 1973–1985. Such trend is found to be stimulated by increased economic activities. Roberts (1990) forecasts US steel consumption up to 2010 using data over the period 1963–1983 and pinpoints to the importance of the gross national product (GNP) in determining metal use. Labson and Crompton (1993) analyze the link between five industrial metals and income for the USA, UK, Japan and OECD for the period of 1960–1987 and discover little evidence of a long-run relationship between the two variables.

Ghosh (2006) studies the link between steel consumption and economic growth in India for the period beginning in 1951–1952 and ending in 2003–2004. He finds no evidence of cointegration but he finds existence of a unidirectional causal effect of economic growth on steel consumption. In similar fashion, Huh (2011) investigates the link between steel consumption and economic activity for Korea over the period of 1975–2008. He discovers evidence of a long-run relationship between total steel consumption and GDP, running from GDP to total steel consumption. Jaunky (2012) studies the link between aluminum consumption and economic growth for 20 rich countries. His study reveals a unidirectional causality running from aluminum consumption to economic growth in the short-run and vice-versa in the long-run.

The testing framework

Econometric tests such as unit root and cointegration tests are necessary before assessing any causal relationship between copper consumption and economic growth. Most of the panel unit root tests are based on an augmented Dickey-Fuller (ADF) unit root test type. Let $LCOP_{it}$ denotes a variable, thus:

$$\Delta LCOP_{it} = r_i + g_i t + \delta LCOP_{it-1} + Z_{im} \sum_{j=1}^{\rho_i} \Delta LCOP_{it-j} + e_{it} \tag{1}$$

where $\Delta LCOP_{it} = LCOP_{it} - LCOP_{it-1}$, t is the time trend, ρ is the lag length and e is the error term. If the null hypothesis (H_0) is accepted (i.e. H_0: $\widehat{\delta} = 0$), then the series is non-stationary. For example, $LCOP_{it}$ is be integrated order of d, i.e. $LCOP_{it} \sim I(d)$, if it were to be differenced by d times to come to be stationary.

As a preliminary step, some time series tests such as the ADF, Zivot and Andrews (1992) and Narayan and Popp (2010) will first be computed for individual countries. Various generations have of panel unit root tests are then to be considered. For instance, first generation tests include those of Levin et al. (2002, LLC), Im et al. (2003, IPS) and Im et al. (ILT, 2005). The ILT test can specifically accounts for endogenous breaks. But, these tests assume independence of individual cross-sections and this is unlikely to hold in practice. Pesaran (2007) further proposes a second generation test which allows for different forms of cross-sectional dependence. Finally as a third generation, Chang and Song (2009) propose a test which can tackle any forms of dependence whether short-run or long-run.

Unit root tests are generally computed via two different regressions. One regression includes a constant term only while the other one includes both a constant term and a time trend. Macroeconomic data usually tend to be non-stationary and exhibit a trend over time. It is therefore more fitting to consider a regression with a constant and a trend at level form. First-differencing tends to remove any deterministic trends in the series. The unit root regression should include a constant term only. For sake of comparison, both regressions are considered.

Next, assuming both series are non-stationary and integrated of the same order, panel cointegration tests can be performed. Pedroni (1999, 2004) was among the firsts to propose testing the panel cointegration. This first generation test assumes cross-sectional independence. With regard to second generation tests, Westerlund (2007) and Westerlund and Edgerton (2008) suggest some panel tests of the H_0 of no cointegration which allows for cross-sectional dependence. The latter allows for unknown structural breaks in both the intercept and slope of the cointegrating regression, which can be located at different periods for different countries. The Westerlund and Edgerton test is supplemented by a bootstrap panel cointegration test with breaks as proposed by Di Iorio and Fachin (2010). As a third generation test, Di Iorio and Fachin (2012) devise a bootstrap panel cointegration test which is robust to short-run and long-run dependence across countries. In the event the residual series is stationary, then the variables are cointegrated.

The relationship between refined copper consumption and economic growth can subsequently be investigated. In the incidence of lack of theoretical support to empirically test this relationship, Granger causality results can provide useful information which can assist the development of new theories or in the refinement of existing ones (Farr et al., 1998). Since, the Granger causality test requires the variables to be stationary, a panel vector error-correction mechanism (VECM) causality test is employed.

The ρth order of a panel VECM structure can be algebraically represented as follows:

$$\begin{bmatrix} \Delta LCOP_{it} \\ \Delta LGDP_{it} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \sum_{k=1}^{\rho} \begin{bmatrix} \phi_{11k} & \phi_{12k} \\ \phi_{21k} & \phi_{22k} \end{bmatrix} \begin{bmatrix} \Delta LCOP_{it-k} \\ \Delta LGDP_{it-k} \end{bmatrix} + \begin{bmatrix} \omega_1 \\ \omega_2 \end{bmatrix} [ECM_{it-1}] + \begin{bmatrix} \kappa_1 \\ \kappa_2 \end{bmatrix} [D_{itb}] + \begin{bmatrix} f_{1i} \\ f_{2i} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \tag{2}$$

where $LCOP_{it}$ and $LGDP_{it}$ denote the natural logarithm of refined copper consumption (in metric tonnes) and GDP (at constant 2000) for country i over year t respectively. The later is usually used to capture economic growth. $i = 1, 2, \ldots, N$, $t = \rho + 1, \rho + 2, \ldots, T$, Δ denotes first differences while α's, ϕ_k's, ω's and κ's are parameters to be estimated. The descriptive statistics of both variables are reported in Table 1. ECM_{it-1} represents the one period lagged error-term derived from the cointegrating vector and the coefficients on the ECMs represent how fast deviations from the long-run equilibrium are eliminated. f_{1i} and f_{2i} are the fixed effects components and the error terms ε_1 and ε_2 are serially independent with mean zero and finite covariance matrix. D_{itb} is the dummy capturing economic shocks which an economy i has been subjected to at a given point in time t. b denotes the point at which the break occurs. The break dates can be obtained from the time-series unit root tests. These dates are utilized as a proxy for economic shocks.

A Wald test for joint significance can be applied to determine the direction of any causal relationship. The results from this test should be interpreted as indicating whether previous changes in one variable contribute significantly to the prediction of the future value of the other variable. Economic growth does not Granger-cause copper consumption if and only if all of the coefficients $\phi_{12k}; \forall = 1, 2, \ldots, \rho$ are not significantly different from zero in Equation (3). The dependent variable reacts only to short-term shocks. These can be referred to as the "*short-run causality*" tests. Another channel of causality can be investigated by testing the significance of the *ECM*s. This test can be denoted as the "*long-run causality*" tests. If no causality is found, then the "*neutrality hypothesis*" holds. Granger causality does not imply true causality (Granger, 1969). For example, if $LCOP_{it}$ Granger-causes $LGDP_{it}$, then $LCOP_{it}$ is useful in forecasting $LGDP_{it}$. According to this framework, "useful" implies the ability of $LCOP_{it}$ to increase the accuracy of the prediction of $LGDP_{it}$ with respect to a forecast, considering only past values of $LGDP_{it}$ (Foresti, 2006).

Dynamic panels tend to suffer from endogeneity problem. The lagged dependent variable appears as an explanatory variable in