



'Nonlinear causality between crude oil price and exchange rate: A comparative study of China and India' – A failed replication (negative Type 1 and Type 2)



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ABSTRACT

Evidence published in this journal by Bal and Rath (2015) purports a bidirectional nonlinear causality between oil price and India's exchange rate and, for China, unidirectional nonlinear causality running from exchange rate to oil price. Their entire testing protocol and ensuing results rest upon claims that all the variables contain a unit root. We raise several critical issues and revisit the order of integration of the series as well as their cointegration and Granger causality properties through a 'pure replication' and a 'reanalysis'. Contrary to Bal and Rath (2015), when we repeat their estimated model with their specification of the Ng and Perron (2001) unit root test on their data, we find that their oil price series (*ROL*) is level stationary (negative replication Type 1), a result which makes all their subsequent results biased and misleading. Our *reanalysis* confirms that *ROL* is $I(0)$, linearly as well as nonlinearly. We also find that the basic bivariate model proposed by Bal and Rath (2015) fails to produce statistically robust and stable cointegrating patterns. Nonlinear causality tests confirm the absence of any nonlinear causality for both countries (negative replication Type 2).

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1. Introduction

The validity and reliability of published results are at the heart of scientific rigor, and yet, verification through replication remains, disappointingly, an undervalued endeavor of economic research. Indeed, aside from sporadic 'Comments' or 'Notes', standard, full-length replication articles rarely appear in the pages of top journals.¹ In their strong call for more replication studies, Burman et al. (2010: 788) emphasize that replication is a critical tool for scientific progress and that the absence of such studies "is particularly problematic because empirical economic research is often prone to error." The inherent value

of the present study lies in contributing to scientific progress by invalidating Bal and Rath's (2015) research findings.

In a recent article in this journal (2015, 51, 149–156), Bal and Rath (henceforth B-R) investigate the nonlinear Granger causality between crude oil price and the exchange rate for both China and India over the period January 1994 to March 2013. They claim to unveil results indicating that all the variables contain a unit root (UR) when the (linear) Ng and Perron (2001) UR test, and the Narayan and Popp (2010) UR test with two structural breaks are performed, and that, when the Hiemstra and Jones (1994) nonlinear Granger causality test is applied to the VAR residuals, a significant bidirectional nonlinear Granger causality between crude oil prices and exchange rates is found for both countries. They also find that when repeating the Hiemstra and Jones (1994) test on the residuals of a GARCH (1, 1) model to check for robustness, their results show that bidirectional nonlinear Granger causality only holds for India, while for China nonlinear causality only runs one way, from exchange rate to oil price.

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¹ For a recent exception, see Herndon et al. (2014).

B-R (2015) raises, in our view, as many questions as it provides answers to, in terms of its ambiguous theoretical premise, the results pertaining to the primary aim of the study, and the econometric procedures applied in pursuit of such aim. We revisit B-R (2015) published results through a 'pure replication' and a 'reanalysis'. Consistent with the harmonizing framework for replications advanced by Clemens (in press), the former exercise is based on *verifying* the original results by *replicating* – using the same model specification, test, and sample –² the exact statistical analysis B-R (2015) conducted in the original paper (up to the point where any discrepancies are found). With regard to the latter, our 'reanalysis' can be classified as a 'robustness test' of their unit root, cointegration and nonlinear causality results but one that retains the same data set, sample period and variable and measures specification adopted by B-R (2015), with the only variant being the estimation or testing techniques employed.³

Arulampalam et al. (1997) draw a similar distinction between the term *replication*, taken to mean using the original data and code to attempt to duplicate exactly the same results as appear in the paper, and *reanalysis*, interpreted as a robustness test that allows for changes in empirical specifications and/or estimation methods. Hamermesh (1997: 107) argues that "The best replication studies [...] will attempt duplication as their starting point, but go far beyond that. They might, for example, [...] try alternative methods and other specifications."

The above framework is broadly consistent with the codes for failed replications proposed by Burman et al. (2010: 789), according to which 'negative Type 1' replications refer to situations where replicating authors "are unable to reproduce the original article's results using the same data, the same specification, and the same econometric software" whereas 'negative Type 2' replications find that the original results are not robust to substantial changes, for example, in terms of functional form or alternative estimation procedures. In the present study we find that B-R (2015) results fail to pass both kinds of replications, Type 1 and Type 2.

Why did we do this? That is, what is the motivation underlying our replication study? Questionable methodological choices and puzzling results aside, what first drew our attention to this paper relates to the ambiguous economic rationale offered by B-R (2015) to investigate the bilateral causality between the real international price of crude oil and exchange rates, notwithstanding the significance that crude oil plays as a form of exhaustible energy tradable in international markets, particularly when examined in relation to countries such as China and India, two of the largest oil-importing countries in the world. Their findings, if proven to be correct, are certainly of importance for the field of energy economics as well as energy finance. Yet it is not immediately obvious why the Indian or Chinese exchange rate should be expected to have an impact on the international price of crude oil, as is their purported finding that both the Indian and Chinese exchange rates have a significant long-run causal effect (nonlinearly). Despite the few empirical studies cited (see their Section 2), their article offers very little in terms of theoretical grounding, leaving the reader puzzled as to what exactly is the theory behind the postulated causal relationship. It is, of course, true that both India and China are relatively large oil importers, but this does not necessarily mean that fluctuations in their national currency or even devaluations could reasonably be expected to impact the oil price in international markets, linearly or nonlinearly.⁴

² This differs from replication by 'reproduction', which is undertaken using a different sample (see Clemens, in press, Table 1).

³ In contrast, according to Clemens (in press, p. 2), an 'extension' (robustness) test entails "using new data gathered on a sample representative of a different population, or gathered on the same sample at a substantially different time, or both." We avoid performing an 'extension' since such robustness test would estimate population parameters that are different from those in the original study and hence generate results that would not be identical in expectation.

⁴ As pointedly observed by an anonymous reviewer, this is particularly the case when considering that, unlike other commodities, the price of crude oil is mainly set by the large oil exporters or OPEC, at least during the estimation period considered.

Additionally, from both an economic and econometric perspective, there appears little justification to assume a simple *bivariate* causal relationship where either the exchange rate is dependent on oil price or vice versa; a premise which makes the model estimated by B-R (2015) highly susceptible to omit variable bias. Oil price is certainly not the main, let alone the unique variable that determines movements in the exchange rate, which – as predicted theoretically – has a number of likely determinants such as inflation, interest rate, and public debt. The same logic applies to the Indian or Chinese exchange rate taken as the sole factor to have explanatory power in the determination of the international price of crude oil (geopolitically driven oil supply disruptions being a case in point). Evidently, ignoring other main determinants may lead to unreliable results. Indeed, a number of studies in the energy literature (e.g., Narayan and Smyth, 2009) show that conducting such bivariate causality exercises might be misleading and it is well established in the econometrics literature that the omission of causality patterns from other theoretically predicted variables can lead to spurious inferences (see Granger, 1969; Lutkepohl, 1982; Triacca, 1998).

There are other econometric gray areas in B-R (2015) that offer scope for critical and empirical scrutiny (as discussed in the next section). First and foremost, their failure to report the UR test results in both levels and first differences for both UR tests conducted, which is, in itself, most unusual.

The nature and structure of our replication adheres to the excellent guidance provided by Burman et al. (2010) in terms of the ground rules and principles for replications, including the expectation for such studies to be presented as standard, full-length manuscripts, to be submitted for peer-review to the same journal where the original research was published, to provide sufficient detail to show that the replication was done correctly and, finally, to attempt first to replicate exactly the original findings by starting with the same data and specification before testing the robustness of the original research through alternative techniques.

The rest of this paper is organized as follows. Section 2 summarizes B-R (2015) analytical steps alongside the gray areas inherent in their methodological choices. Sections 3 and 4 present and discuss our results obtained from a *pure replication* and a *reanalysis*. The final section concludes.

2. Bal and Rath (2015) analytical steps and 'gray areas'

The analysis reported in B-R (2015) begins with presenting plots of the rates of change between crude oil price and the real effective exchange rate (REER) of India and China, the visual inspection of which leads them to infer ('assume' rather) that a nonlinear relation exists between the variables, for both countries.⁵ They then perform the Ng and Perron (2001) UR test, and the Narayan and Popp (2010) test with two structural breaks (in level and trend). These *linear* tests are performed on the raw data series rather than their log form, a very uncommon yet potentially legitimate choice since the natural logarithmic transformation may induce a linearization of the raw data. For the Ng and Perron (2001) test, only evidence of the stationarity of

⁵ We use the original data set, which Bal and Rath provided to us. In terms of the definition of the variables, B-R (2015: 152) state: "The real effective exchange rate of India (RIX), obtained from the official website of the Reserve Bank of India published in the Handbook of Statistics on Indian Economy, was used in this study. The real effective exchange rate of China (RCX) was obtained from the CEIC database, a product of the Euromoney Institutional Investor Company. The crude oil price, taken in real terms and deflated by the US consumer price index following Faria et al. (2009), was defined as the spot price of West Texas Intermediate (WTI), a definition obtained from the Energy Information Administration, US Department of Energy. The data for crude oil prices (ROL) and the US consumer price index were obtained from the CEIC database." According to our inspection of these databases, both exchange rate measures would appear to be based on domestic currency in terms of foreign currency and adjusted for relative price levels, with an increase in RIX or RCX indicating a real appreciation of the domestic currency.

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