COMMODITY PRICES IN EMPIRICAL RESEARCH

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Abstract

Commodity prices are key ingredients in many economic theories. We pick three of them (Prebisch-Singer Hypothesis, commodity currencies, financialization of commodity markets) and give a critical view on the empirical challenges faced by practitioners, including measurement inconsistencies, endogeneity concerns, time series properties and empirical design.

Keywords: Prebisch-Singer Hypothesis; Commodity currencies; Financialization; commodity prices

1. Introduction

Commodity prices are ingredients involved in many fields in economics. They are associated to natural resource curse in development economics, to trade policies in international economics, to diversification benefits in portfolio management, to commodity currencies in international finance, to civil wars and international conflicts in political economics, to the price puzzle in monetary economics. The empirical treatment of commodity prices has naturally followed a logic specific to each discipline, with empirical assumptions that have neither been harmonized, nor compared with each other. This monograph is designed to trigger a dialogue and tentatively bridge some gaps by highlighting the empirical concerns associated to the commodity prices in their diversity and by illustrating the various solutions proposed to deal with potential endogeneity, with non-stationarity and with data measurement.

We pick three emblematic topics involving the commodity prices and we detail for each of them what empirical challenges do the commodity prices raise and how they are handled. The first topic consists in the existence of a long-run declining trend in commodity prices, the so-called Prebisch-Singer Hypothesis. The second topic refers to the dependence of exchange rates of some commodity exporting countries to the international commodity prices, that is, commodity currencies. The last topic builds on the rising weight of financial investors on the commodity markets and on their impact on commodity prices, what has been called the financialization of commodity markets.

We focus on these three topics for the following reasons. These topics allow us to make a comparison of treatments from three different fields, namely development economics, international economics and finance. Further, these perspectives provide three different approaches on commodity prices. In the first topic, the Prebisch-Singer Hypothesis, commodity prices are studied as such, in isolation from any other influence in a univariate setting. Inversely, the two other topics take the commodity prices as one variable among others in a multivariate setting. Commodity currency papers view commodity prices as a right-hand side exogenous variable, while the financialization literature sees commodity prices as a left-hand side endogenous variable.

2. Prebisch-Singer Hypothesis

2.1 Introduction

Terms of trade, defined as the ratio of export prices to import prices, have an impact on the macroeconomic performance of large exporters. A rising terms of trade signals a gain from international trade for that country, as it can pay for more imports per export units, which can ultimately translate into a more vivid economic growth (Collier and Goderis 2012).

For developing countries with commodities as main exports (energy, metals, agriculturals), the terms of trade consists in a ratio of country specific commodity prices to import prices, which mainly consist in manufactured goods. Consequently, for these countries, the terms of trade are sometimes proxied by a commodity terms of trade, where the numerator reflects the evolution of the prices of the sole commodity exports.

Prebisch (1950) and Singer (1950) suggested, in what is known as the Prebisch-Singer Hypothesis (PSH), that the commodity terms of trade should decline in the long-run, as the income elasticity of demand for commodities is less than that of manufactured goods. Economic policies should thus consider protectionist policies and help commodity dependent countries in diversifying their economies out of commodity exports and thereby to alleviate the negative long-run contribution of declining commodity prices.

The PSH was in conflict with the view of classical economists such as Ricardo, Malthus, Mill and Jevons in the nineteenth century, who emphasized that commodities are characterized by physical finitude: arable land is limited by earth surface and minerals, such as oil and metals, have a limited available stock in the ground. Due to this inexorable limitedness, commodity prices, that is, terms of trade of developing countries, should rise in the long-run, not decline (Hallam 2018).

Ultimately, whether the long-term trend of relative commodity prices is ascending or declining is an empirical question. As discussed below, and summarized in Table 1, a remarkable amount of empirical papers has been devoted to this question. We first show the different approaches followed in the literature to measure the (commodity) terms of trade and then discuss the incremental sophistications of the econometric strategies.

2.2 How to measure the terms of trade

2.2.1 Proxies

The empirical papers have progressively changed the focus variable of the PSH, going from the terms of trade, which is a country specific measure, to a ratio of commodity to manufacture prices, that is, no longer a country specific measure.

Different variants of this ratio of commodity to manufacture prices are found in the literature. Some studies focus on commodity indices, some on sub-indices (metals, energy, agriculturals) and others on specific commodities (oil, copper). The research question should drive the choice of the right measure.

The single commodity approach is relevant for considering specific countries highly dependent on one commodity, as is the case of Chile for copper or of Saudi Arabia for oil. This approach is sometimes required by the econometric strategy, when we test the PSH with panel approach for example, in which case the single commodities are used as panel units for example.

Alternatively, many papers rely on commodity price indices, as set out in Equation (1).

$$COMP_t = \sum_{h=1}^{H} w_h P_{ht} \qquad (1)$$

where $COMP_t$ is the commodity price index, where P_{ht} is the logarithm of the price of commodity h, where H is the number of commodities considered in the index ($H=24$ in the Grilli-Yang nonfuel commodity price index) and where w_h is the time-invariant weight associated to commodity h. The weights can be based on average shares of each commodity in world exports as in Grilli-Yang index or be equal to $1/H$ if we take equal weights.

Aggregation provides benefits and pitfalls. It has the benefit of offering a summary view of commodities in general, cleaning from commodity specific noise but also removing their large heterogeneity. However, if the PSH is validated on an aggregate measure of commodity prices but not on single commodities, can we really neglect this inconsistency, given that many countries depend on one single commodity (typically crude oil)? Moreover, aggregation issues might arise. As an illustration, Cuddington (1992) tested the PSH separately on 24 commodities and found no break in any country in 1921, while a break was found for the aggregate commodity index (built as the trade-weighted average of the 24 series). Keeping in mind the context of the PSH, we would recommend to not discard too fast individual commodity measures, as there is certainly no developing country exporting a commodity basket similar to the aggregated ones.

2.2.2 Deflators

The PSH refers to a relative price where the denominator is expected to capture the evolution of import prices in developing countries. Three proxies are usually considered: the Manufacturing Unit Values index, the U.S. manufacturing price index and the Consumer price indices.

The Manufacturing Unit Values, or MUV, is a trade-weighted index of developed countries' (24 countries in the current version) exports of manufactured goods to developing countries. It is built from UNCTAD's Handbook of Statistics database and from IMF's World Economic Outlook database (Spatafora and Tytell 2009). It covers the period after 1900 with some gaps for 1914-1920 and 1939-1947 that have been filled by interpolation by Grilli and Yang (1988) and updated notably by Pfaffenzeller (2012). This proxy is by far the most frequently used (see for example Aslam et al. 2016).

The US manufacturing price index was derived by Grilli and Yang (1988) as an index of domestic prices of manufactured products in the U.S. netting out energy, timber, and metal prices from the U.S. wholesale price index of industrial commodities. The key weakness of this indicator is that it only considers the mix of manufactured goods exports of one sole industrial country and also relies on the, strong, assumption of the law of one price whereby manufactured products prices in the US reflect the international prices.

The consumer price indices from major economies is a widely available alternative deflator. However, this proxy includes nontradables, which unduly distort the terms of trade flavour that we want to capture.

As an alternative, commodity terms of trade could be measured against a price index of service sector outputs rather than manufacture, given the growing economic importance of the service sector. This suggestion certainly gains relevance as the weight of services reaches 23% of total world trade, growing by more than 7% in 2018, with the US and EU accounting together for 44% of world service trade.

2.2.3 Datasets

The most widely–used dataset is the one developed by Grilli and Yang (1988). Their indices are mainly based on World Bank commodity price data. Grilli and Yang considered 24 nonfuel individual commodities: aluminium, bananas, beef, cocoa, coffee, copper, cotton, hides, jute, lamb, lead, maize, palm oil, rice, rubber, silver, sugar, tea, timber, tin, tobacco, wheat, wool and zinc. They construct an all commodities price index and three sub–indices for agricultural food commodities, non–food agricultural commodities and metals. The indices are base period trade–weighted arithmetic averages of the commodity prices concerned. They also provide an alternative geometric average version of the same (sub-)indices. Grilli and Yang's original series ran from 1900 to 1986 but has been updated by a number of researchers (Pfaffenzeller (2012)).

For studying long–run price trends, the longer the series, the better. *The Economist* commodity price index goes back further to 1845, as used by Cashin and McDermott 2002. Harvey *et al*. (2010) assemble some data series back as far as 1650. Ensuring consistency and continuity over such a long period remains of course inexorably subject to cautious interpretations. Given the long-term perspective of the PSH, most researchers deal with annual frequency. Relying on monthly commodity price series of the World Bank, available as from 1960, would not bring additional relevant information.

2.3 Review of econometric strategies

We review the PSH empirical papers by presenting successively the trend-stationary and difference stationary models. We then detail the different approaches designed to addressing the potential structural breaks and finally present the extensions based on panel methodologies. This chronological review is summarized in Table 1.

2.3.1 Deterministic trends

First, let's assume that the relative commodity price series is generated by a trend-stationary (TS) data process as follows

$$COMP_t = \alpha + \beta t + \varepsilon_t \qquad (2)$$

where $COMP_t$ is the logarithm of the commodity price indice, where t is an annual deterministic trend, where ε_t is a stationary process with mean equal to zero, an ARMA for example, and where the sign and significance of β lead to conclusions on the PSH. Most studies based on this methodology (Sapsford (1985), Grilli and Yang (1988)) found support to the PSH, in other words β was found to be significantly negative.

Of course, these conclusions are subject to the validity of the stationarity assumption. Non-stationarity of the error terms could lead to spurious rejection of the null $\beta = 0$ and to spurious support of the PSH. Cuddington and Urzua (1989) were the first to carry out unit root tests on the Grilli-Yang commodity price dataset. Similarly, Kim et al. (2003) showed that the 24 commodity price series contained in the standard Grilli-Yang commodity price index are characterized by unit-root behaviours (18 commodities) or quasi unit roots (6 commodities). Similar results were reported by Cuddington (1992) and Newbold *et al.* (2005).

2.3.2 Stochastic trends

Consequently, we can assume that the relative commodity price series are generated by a difference-stationary (DS) process as follows

$$\Delta COMP_t = \beta + u_t \qquad (3)$$

where ΔP_t is the differenced logarithm of the commodity price index, where u_t is a stationary process, an ARMA for example, with mean equal to zero, and where the sign and significance of β leads to conclusions on the PSH. Kim et al. (2003) accounted for non-stationarity and find much less support to the PSH. Indeed, using the same 24 commodity prices of the Grilli-Yang database, they observe that the null hypothesis of $\beta = 0$ is much less frequently rejected with a non-stationary process specification than in stationary models.

The finding that most commodity price series largely behave like random walks, is not anodine. A shock to the price of, say, copper today would thus be permanent. Copper price would no longer revert to any stable, long-run values/trends. As a consequence, stabilization mechanism as the one implemented by Chile, whereby asset accumulation is conditioned on copper prices being above a long-term level, would theoretically no longer be sustainable as it relies on the concept of a stable level/trend.

Detection of unit roots remains subject to some caution. It might be spuriously derived from a bad specification of the data generating process or due to the well-known lack of power of standard non-stationary tests (Schwert, 1987). We now consider extensions related to these two possibilities and see that the conclusions supporting the PSH lose their strength.

2.3.3 Breaks

Structural breaks contribute to hiding the mean reversion behavior of a series. They can lead the econometrician to erroneously conclude to non-stationarity. Modelling breaks explicitly is therefore a key part of the empirical strategy. Let us now consider a general specification allowing for breaks before discussing the different choices open to the econometrician:

$$\Delta COMP_t = \beta + \sum_{k=1}^{K} \delta_k D_{kt} + \sum_{k=1}^{K} \gamma_k DU_{kt} + u_t \quad (4)$$

where $\Delta COMP_t$ is the differenced logarithm of the commodity price index, where K is the number of breaks, where D_{kt} is an indicator variable designed to capture breaks in the level and taking the value 1 if t is equal to the break date τ_k, the value 0 otherwise, where DU_{kt} is an indicator variable designed to capture breaks in the trend and taking the value 1 if t is equal to, or larger than, the break date τ_k, the value 0 otherwise, and where u_t is a stationary process with mean equal to zero, and where the sign and significance of β again leads to conclusions on the PSH.

We must first decide whether break dates are set exogenously or endogenously. The determination of break dates can rely on graphical or other external bases. As an illustration, Grilli and Yang (1988) tested the robustness of their results by imposing three breaks in 1921, 1932 and 1945, based on visual inspection. Cuddington and Urzua (1989) found breaks in 1921 and ("*to a lesser extent*") in 1974. Alternatively, we can let the data speak and determine endogenously the break dates (or confirm the ones visually detected).

Leon and Sotto (1995) relied on the Zivot and Andrews (1992) tests by allowing the position of the break to be endogenously determined at the point at which the null hypothesis of a unit root is more easily rejected against the competing alternative TS representation with shifts in either the level or the trend of the series. They showed that the unit roots found for 12 commodity price series by Cuddington (1992) were potentially related to misspecification problems, as they rejected the null of non-stationarity for 8 of their 12 series.

While the Zivot and Andrews (1992) test allows for one break (*K=1*), Lumsdaine and Papell (1997) extended their methodology from one to two endogenously chosen break dates (*K=2*). Allowing for up to 2 breaks, Kellard and Wohar (2006) found that 14 commodity price series, out of 24, were characterized by trend-stationarity.

These tests are questionable. There is a potential size distortion in the Zivot-Andrews and Lumsdaine-Papell approaches that can lead to spurious rejection of the null hypothesis of a unit root when the actual time series process contains a unit root with a structural break. Indeed, these approaches only allow for structural breaks under the alternative hypothesis and assume a liner non-stationary series under the null. Lee and Strazicich (2003) therefore proposed a minimum two-break LM test allowing for structural breaks under the null hypothesis. This test does not suffer from the size distortion discussed above. Using this methodology, Ghoshray (2011) found that 11 of the commodity price series were difference-stationary, while the 13 other series were stationary with either 1 or 2 structural breaks but with no significant trend, thereby further weakening the support to the PSH.

Finally, and more critically, we should not lose sight of the underlying research question on the long-run trend of relative commodity prices. Identifying breaks is relevant and helps in building well-specified models, but neutralizing them, say sudden collapses, leads to underestimating the long-term trend.

2.3.4 Panels

Low power of non-stationary tests can also be addressed by considering a panel approach. Testing jointly the non-stationary of a set of commodity prices increases the power of the test relatively to testing individually each time series. This is the approach followed recently by Arezki et al. (2014), who considered panel stationary tests allowing for multiple endogenous breaks, with mixed support to the PSH. Di Iorio and Fachin (2018) similarly relied on panel cointegration methods but restricted their analysis to the "*post-colonial era*" and did not find support to the PSH, except for agricultural goods over the 1950-2011 period.

These approaches have the merit to partially account for heterogeneity of the commodity price series (via fixed effects) and in this sense dominate analyses based on simple commodity price aggregation (such as Grilli-Yang indices).

2.3.5 Other extensions

By considering breaks, these empirical studies identify different periods (or regimes) that might be characterized by different dynamics. This can justify finer estimation methodologies such as piecewise linear regression approaches (Arezki et al., 2014) or quantile regressions incorporating unknown numbers and forms of breaks through a Fourier function (Bahmani et al. 2018).

Kellard and Wohar (2006) note that "*for the majority of commodities, the trend is not well represented by a single downward slope, but instead by a shifting trend that often changes sign over the sample period*". They propose a measure of the prevalence of a negative trend (deterioration exists for more than 70% of the sample period) and find that 8 commodity price series have a prevalent negative trend, a quite small support to the PSH. Instead of isolating a dominant trend, Yamada and Yoon (2014) estimate the piecewise linear trends of the relative primary commodity prices series and note that the PSH has become substantially weaker over the last decade.

Table 1 - PSH – review of empirical papers

	Methodology	Results
Grilli and Yang (1989)	TS approach on commodity indices. Breaks dating based on visual analysis.	Index of commodity prices decline by 0.5% per year, and non-fuel commodity prices by 0.6% per year. Breaks in 1921, 1932, 1945.
Cuddington and Urzua (1992)	TS and DS approaches on commodity indices. Breaks tested with dummies.	Neither specification indicates evidence of secular deterioration in commodity prices, but only a permanent one-time drop in prices after I920.
Cuddington (1992)	TS and DS approaches on individual commodity price series. Breaks tested with dummies.	Half the series are TS, other half DS. 5 of the 26 individual commodity price series have a significantly negative trend. No break in 1921 for individual series, while break is found in index (aggregation concern).

Leon and Sotto (1995)	TS and DS approaches on individual commodity price series. Recursive unit-root test of Zivot-Andrews (1991) to account for endogenous breaks.	5 of the 24 series are DS. 19 series are TS (with or without breaks). After consideration of endogenous breaks, 15 of the 24 series have a significantly negative trend.
Kim et al. (2003)	Tests accounting for the uncertainty in choice of TS vs DS processes. Estimates on individual commodity price series. No consideration of breaks.	They find "*at least modest evidence of trend in only 8 of the series, and in just 6 of these was that of downward trend*".
Kellard and Wohar (2006)	Unit root test of Lumsdaine and Papell (1997) that allows for two shifts in the mean and trend under the alternative hypothesis to individual commodity price series.	14 series are trend-stationary after allowance for (up to) two breaks. Furthermore, for the majority of commodities, the trend is not well represented by a single downward slope, but instead by a shifting trend that often changes sign over the sample period.
Ghoshray (2011)	Unit root test of Lee and Strazicich (2003) who developed a test which incorporates structural change in the null hypothesis. On individual commodity price series	11 out of 24 commodity prices are found to be DS. The remaining 13 prices are found to exhibit TS behavior with either one or two structural breaks. Most of the commodities that do not exhibit DS behavior seem to contain no significant trends.
Yamada and Yoon (2014)	Estimation of piecewise linear trends on individual commodity price series. Number of breaks is not fixed a priori.	Only one commodity has a negatively sloped trend function throughout the whole sample period. Most commodities exhibit negatively sloped trends during some of the sample periods (PSH only holds locally). Strength of PSH weaker during the last decade.
Arezki et al. (2014)	Use of the extended dataset of Harvey et al. (2010) starting in 1650. Panel data stationarity tests that allow for endogenous multiple structural breaks. Piecewise linear regressions on 25 commodity series.	4 commodities have 1 break, 13 have 2 breaks, 7 register 3 breaks and 1 (gold) has 4 breaks. Out of the total of 80 slope estimates, 41 are negative and significant, 11 are negative but insignificant, 21 are positive and significant finally, 7 are positive and insignificant.
Di Iorio and Fachin (2018)	Panel cointegration bootstrap test on 3 commodity sub-indices. Restricted sample from 1955 onwards.	PSH rejected over the 1950–1980 period. Rejection not confirmed over the entire 1950–2011 sample for agricultural commodities.

Note: TS and DS stand for trend/difference stationary, respectively.

2.4 Discussion

First, the abundance of studies on the PSH, that we summarize chronologically in Table 1, has probably brought more confusion than clarity. The interpretation of breaks, incorporated in most studies, is rarely straightforward. Is a sharp downward break just noise to be neutralized? or a shift revealing a secular declining trend? The econometric approach should inevitably be complemented by well justified assumptions on which breaks are exogenous (due for example to wars or climatic events) and which ones are sharp adjustment contributing to the long-run trend (as the 1973 OPEC embargo for example). In principle, only the former should be neutralized. Few papers discuss the nature of the breaks (Di Iorio and Fachin, 2018))

Second, the comparison benchmark of manufacture price is far from perfect, as: a) it imperfectly proxies the manufacturing import of commodity exporting countries; b) it does not correct for manufacturing quality, which likely biases downward the estimates of the trend coefficient β; and c) it does not include the price of the services that are a growing share of the global imports.

Finally, super-cycles of commodity prices have also found some support in a parallel literature on commodity price booms and busts. Empirical studies investigating the PSH might take on board explicitly these developments.

Coming back to the PSH, and according to the review Table 1, we find that the more sophisticated the methodologies the weaker the support to the PSH.

3. Commodity Currencies

3.1 Introduction

The real exchange rate of some commodity exporting countries is driven by the fluctuating relative prices of the commodities they export, in other words their terms of trade. We call commodity currencies the currencies of such countries. Typically, it refers to currencies of Australia, Norway, Chile or Ivory Coast. Before discussing empirical evidences on such dependence between real exchange rate and commodity prices, we first present the relevant definitions of the real exchange rate, then discuss the measurement issues of both commodity prices and real exchange rates and finally present the economic strategies designed for measuring the role of the terms of trade on the real exchange rate. We see that the arbitrary choices on measurement and methodologies have substantial consequences on the analysis.

3.2 RER models

A common definition of the real exchange rate[1] is the nominal exchange rate adjusted by price levels:

$$RER_t \equiv s_t - p_t^* + p_t \quad (5)$$

Where *RER* is the real exchange rate, where s is the log exchange rate defined in units of foreign currency per unit of home, that is, s rising is an appreciation of the home currency, and p and $p*$ are log price levels, an asterisk denoting foreign or international prices. Now suppose the price index is a geometric average of traded and nontraded good prices, then:

$$p_t = \alpha\, p_t^N + (1-\alpha)\, p_t^T$$

$$p_t^* = \alpha^*\, p_t^{N^*} + (1-\alpha^*)\, p_t^{T^*}$$

Substituting the price indices decomposition into the real exchange rate formula and re-arranging yields:

$$RER_t \equiv \left(s_t - p_t^{T^*} + p_t^T\right) + \alpha\,(p_t^N - p_t^T) - \alpha^*(p_t^{N^*} - p_t^{T^*})$$

This decomposition indicates that the real exchange rate can be expressed as the sum of three components: (i) the relative price of tradables, (ii) the relative price of nontradables in terms of tradables in the home country, and (iii) the corresponding relative price in the foreign country.

For the simplifying case where the weights of nontradables in the aggregate price indices are identical, the second and third terms can be collapsed into an intercountry relative price of nontradables:

$$RER_t \equiv \left(s_t - p_t^{T^*} + p_t^T\right) + \alpha\,(\hat{p}_t^N - \hat{p}_t^T) \quad (6)$$

where the circumflex denotes the intercountry log difference.

Firstly, if one assumes the law of one price holds for all goods, and consumption baskets are identical, then both terms on the right-hand side of Equation (6) are zero, and PPP holds (since

[1] This section borrows from the primer on real effective exchange rates of Chinn (2006).

there are no nontradables by definition). That is, the real exchange rate is a constant, far from empirical evidence.

Secondly, if instead PPP holds only for tradable goods, then the first term is zero, and the relative tradables-nontradables price is the determining factor in the value of the real exchange rate. Fundamentals or mechanisms affecting the relative tradables-nontradables price include productivity differentials (Balassa (1964), Samuelson (1964)), differentials in production factor endowments (Baghwati (1984), Bodart and Carpantier (2016)), government consumption (Ostry (1994)), fertility (Rose, Supaat and Braude (2009)), etc.

Thirdly, another possibility is that all goods are tradable, but not perfectly substitutable; then one has an imperfect substitutes model. Both terms on the right-hand side of the above equation can take non-zero values. The imperfect substitutability means that the dynamics of export prices and import prices can be different. This imperfect substitutability can have different sources, such as imperfect mobility of capital or differences in natural resource endowments (specialization assumption in the models developed in Choudhri and Khan (2004)). Papers relying on, or extending, these specific models relating terms of trade to real exchange rates include De Gregorio and Wolf (1994), Chen and Rogoff (2003), Cashin et al. (2004), Choudhri and Khan (2004), Ricci, Milesi-Ferretti and Lee (2013), as well as Bodart et al. (2012, 2015)).

Commodity currencies models are derived from this imperfect substitutability definition of the real exchange rate.

3.3 How to measure the real exchange rate

3.3.1 Bilateral vs effective

Similar to nominal exchange rates, real exchange rates can be computed on a bilateral or on an effective basis.

In their seminal contribution, Chen and Rogoff (2003) studied commodity currencies with exchange rates expressed in USD. One obvious limit of bilateral exchange rates is that it does not isolate from factors that are specific to the reference currency area, namely the dollar zone. Checking the robustness of the results on alternative currencies is a necessity when working with bilateral exchange rates. Chen and Rogoff therefore compared their results with those obtained with exchange rates expressed in GBP.

Most studies on commodity currencies (Cashin et al. (2004), Bodart et al. 2012, 2015, Coudert et al. 2011) rely on the effective version of the exchange rate, defined as trade-weighted multilateral real exchange rate, where the weights are specific to each country trade network, as set out in the Equation (7)

$$RER_{it} = \sum_{j=1}^{J} w_{ij} \, RER_{ijt} \tag{7}$$

where RER_{it} is the real effective exchange rate of country i, RER_{ijt} is the real bilateral exchange of country i with country j, where w_{ij} is the weight associated to RER_{ijt} and where J is the number of countries considered in the real effective exchange rate formula of country i. Such series are available from IMF IFS database, or alternatively from Darvas (2012).

The strength of effective rates is that real exchange rates are measured in terms of a basket of currencies, thereby diluting the fluctuations due to country j shocks. The weakness is that the basket is country specific, that is, w_{ij} depends on i. Using country specific trade weights is mainly justified for studies focusing on competitiveness. An alternative is to use a fixed basket of currencies (in the vein of special drawing rights or of the Libra), set identically for all investigated countries, that is, $w_{ij} = w_j$ in Equation (7). Chen and Rogoff (2003) took this option by replicating their analysis on Canada, Australia and New-Zealand by looking at the exchange rate with the so-called Broad Index, a composite of over 30 non-US-dollar currencies. Surprisingly, this interesting practice has not been much followed.

3.3.2 Real vs nominal

As discussed by Chinn (2006), we often face a trade-off between using the most appropriate real exchange rate measure conceptually, and the most readily available data.

In practice, one only has a choice of a few price deflators. At the monthly frequency, they include the consumer price index (CPI), producer price index (PPI), wholesale price index (WPI) and export price index. At lower frequencies, such as quarterly, the set of deflators increases somewhat, to include the GDP deflator, unit labor costs and price indices for the components of GDP, such as the personal consumption expenditure (PCE) deflator.

Typically, the CPI is thought of as weighting fairly heavily nontraded goods such as consumer services. Similarly, the GDP deflator and the CPI weigh expenditures on nontradables in proportion to their importance in the aggregate economy. In contrast, the PPI and WPI exclude retail sales services that are likely to be nontraded.

Due to availability constraints for long periods and the need of a large enough set of developing countries, most studies use CPI-real exchange rates (Chen and Rogoff (2003), Cashin et al. (2004), Bodart et al. (2012, 2015)), as provided by the IMF-IFS database for a wide set of countries and years.

Clearly, for purposes of calculating the relative price of goods and services that are tradable, the preferred measure would have been the exchange rate deflated by PPIs or WPIs were the data available. It is worth noting that a recent empirical paper of Ahn, Mano and Zhou (2017), compared CPI, GDP and ULC deflators in the context of the expenditure switching mechanism studies. It supports Chinn (2006) statement that the choice of the deflator may have considerable effects on the empirical conclusions.

3.4 How to measure commodity dependence

3.4.1 Commodity dependence definitions

Commodity dependence is typically measured by the share of commodity export earnings in total exports (IMF), in total merchandise exports (UNCTAD), and in GDP. Alternatively, commodity dependence can be measured by the percentage of people engaged in the production of commodities or by the share of government revenues due to commodity production and exports.

Part of the commodity currency literature picks some specific countries, without requiring any criterion, thereby presuming their commodity dependence, such as Russia, Saudi Arabia and Norway in Habib and Kalamova (2007), or Australia, Canada, New Zealand and South Africa in Chen and Rogoff (2003), Algeria in Koranchelian (2005) or Peru in Tashu (2015).

Another part of the literature casts the net wider by considering more systematically groups of countries specialized in commodities (Cashin et al. 2004, Bodart et al. 2015), or sub-groups such as energy (Coudert et al. 2011, Dauvin 2015). The main criterion used in this category of studies is the one originally set by the IMF where a country is classified as a commodity exporter when its primary commodity exports (categories SITC4 0, 1, 2, 3, 4 and 68 of the Standard International Trade Classification) account for at least 50 percent of the value of total exports of goods and services on average over a given time window. The list of countries accordingly established in Cashin et al. (2004) has been used in many subsequent studies.

A new IMF definition from Aslam et al. (2016) sets a dual criterion that commodity exporters are emerging market and developing economies for which gross exports of commodities constitute at least 35 percent of total exports and net exports of commodities constitute at least 5 percent of exports-plus-imports on average. This new criterion of net export is certainly relevant as it helps in excluding the commodity exporting countries that are large commodity importers. We expect indeed the export commodity price fluctuations to be offset by the import ones when the net export of commodities is not positive and large enough.

3.4.2 Commodity Basket

The literature is divided on the way to build the relevant commodity price series. The least relevant approach in our context would be to relate the real exchange rates to a world commodity price index. Such approach would be appropriate if countries were dependent on the same commodities (which is not the case) or if the commodity prices were highly correlated (which is not the case). The commodity currency literature then only considers country specific commodity price indices based on the country specific commodity exports.

The first approach, followed by Chen and Rogoff (2003), Cashin et al. (2004) and Coudert et al. (2011), considers a country-specific commodity price index, $CToT_{it}$, constructed as follows

$$CToT_{it} = \sum_{h=1}^{H} w_{ih_i} P_{h_i t} \tag{8}$$

Where $P_{h_i t}$ is the logarithm of the price of the commodity that ranks at the h-th position in commodity exports of country i, where w_{ih_i} is the weight of that commodity in commodity exports (Cashin et al., 2004) or home production (Chen and Rogoff, 2003) of country i, normalized such that the weights sum to one, where H is the number of most exported commodities considered for the formula (H=3 in Cashin et al. (2004) and H=5 in Coudert et al. (2011)).

The second approach, that is used in Habib and Kalamova (2007) and Bodart et al. (2012, 2015), assesses whether the price of the top commodity exported by a country ($P_{1_i t}$) is an economically and statistically significant determinant of the long-run variations in their real exchange rate, therefore focusing on a single price rather than a constructed price index.

The relevance of these two approaches depends on the context. One the one hand, weighted averages provide finer measures of the commodity dependence, as they incorporate a richer set of information. On the other hand, the top commodity approach closely reflects the policy focus on a single commodity that we have in many oil exporting countries, in Chile for copper, or that we had in Columbia for coffee (Edwards, 1986) or in South Africa for gold (McDonald and Ricci 2004).

3.4.3 Deflators

In order to capture properly the relationship between real exchange rates and commodity prices, the latter have to be expressed in real terms (similarly to terms of trade). Following the practice of the PSH literature, commodity prices, or indices, are deflated by the IMF's index (of the unit value) of manufactured exports (MUV) expressed in US dollars. The use of the MUV index as a deflator is common in the commodity price literature and considered as a proxy of the price of developing country imports of manufactures (see for example Deaton and Miller (1996) and Cashin et al. (2004)).

3.5 Review of econometric strategies

3.5.1 Introduction

The choice of the empirical strategy best suited for assessing the elasticity of the real exchange rate to the commodity price index is generally preceded by a careful analysis of the stationarity of the series. Indeed, conclusions on the stationarity of the real exchange rate and of commodity prices are rarely clear-cut. Often, the papers devote a paragraph on diverging outcomes from alternative non-stationarity tests (Chen and Rogoff 2003, Ricci et al. 2008, Habib and Kalamova 2007, Bodart et al. 2012). Ultimately, most papers rely dominantly, or exclusively, on methodologies designed for non-stationary series. Those papers integrating an analysis designed for stationary series mainly rely on simple OLS regressions, with deterministic trend (Chen and Rogoff 2003) or with lags of commodity price index (Habib and Kalamova 2007). We now present the non-stationarity approaches that dominate, by far, the commodity currency empirical literature.

3.5.2 Cointegration models

Most empirical papers on commodity currencies mainly rely on cointegration methods, which are characterized by 3 standard steps: first, documenting the non-stationarity of the series via standard unit root tests; second, testing the cointegration of the real exchange rate with the commodity price index via Engle and Granger cointegration tests (Cashin et al. 2004), or Johansen cointegration tests (Habib and Kalamova 2007); and finally estimating the cointegration coefficient through dynamic OLS (DOLS) or fully modified OLS (FMOLS).

Country specific cointegration analyses rely on the following equation:

$$RER_t = \alpha + \beta_0 CToT_t + \sum_{l=1}^{L} \beta_l X_{lt} + \varepsilon_t \qquad (9)$$

where RER_t is the logarithm of the real exchange rate, where $CToT_t$ is the logarithm of the real price of commodity exports, that is, the country-specific commodity terms of trade, where the X_{lt}s are a set of control variables, such as net foreign assets, productivity differentials, government consumption and trade restriction index (see the review of Ricci et al., 2008), where ε_t is a stationary process with mean equal to zero and where RER_t and $CToT_t$ are both I(1). The significance of β, the coefficient of interest, indicates whether the country is characterized by a commodity currency profile or not.

Such analysis has been carried out systematically by Cashin et al. (2004) on a set of 58 countries based on country specific regressions. They found evidence in support of the long-run co-movement of real exchange rate and real commodity-export price series for about one-third of the commodity-exporting countries. The median value of the elasticity β_0 is 0.42, indicating that a 10% rise in real commodity prices is typically associated with a 4.2% appreciation of the real exchange rate.

These results on non-stationarity, cointegration and on elasticity estimation are subject to limitations due to low power of the tests, to omission of breaks, or to endogeneity issues. We now discuss the different solutions proposed in the literature to tackle these limits.

3.5.3 Panels

The panel approach expands the pool of observations and helps in reaching better power for the tests. It is also a convenient framework when we aim at interacting elasticity with country specific variables such as currency regime or financial openness in a single step estimation (Bodart et al. 2015).

This is not the aim of this contribution to review panel cointegration methodologies but to highlight commodity currency specificities. A key one refers to the degree of cross-sectional dependence of both real exchange rates and commodity prices. Indeed, we can suspect real exchange rates to be cross-sectionally dependent by construction. For example, we might expect from close trading partners, such as Canada and the USA, to have effective real exchange rates $RER_{USA,t}$ and $RER_{CAN,t}$ negatively correlated. Similarly, we can expect commodity prices, say $CToT_{gas,t}$ and $CToT_{oil,t}$, to be positively correlated. Cross-sectional dependence tests, such as the one of Pesaran (2004), confirm these presumptions (Bodart et al.

2012). Since original panel cointegration tools were assuming cross sectional independence ($RER_{i,t} \perp RER_{j,t}$ and $CToT_{i,t} \perp CToT_{j,t} \; \forall \; i,j$), these were, for commodity currency empirical analyses, not supported by the data. A second generation of panel cointegration methods was then developed (see Breitung and Pesaran 2005, Hurlin and Mignon 2007 and Hadri et al. 2015 for reviews), robust to cross-sectional dependence.

As discussed in the PSH section, commodity prices are subject to breaks over long periods. A third generation of non-stationary panel tests has emerged, which allows for breaks (Westerlund and Edgerton (2008) and Banerjee and Carrion-i-Silvestre (2015)). The same caveat applies here as to the interpretation and treatment of breaks. In addition, the difficulties expand in a bivariate and panel context. First, we might have two non-synchronous breaks, one affecting the real exchange rate, the other the commodity price index. Whether such breaks should be neutralized or not, depends on whether we allow for potential delayed response of the real exchange rate to large commodity price shocks. Second, whether breaks should be country specific or global is another arbitrary choice that affects the tests and elasticity estimates. Needless to say, that choices made by the econometrician need a careful justification.

3.5.4 Endogeneity concerns

The point of working with the commodity component of the terms of trade rather than with the standard terms of trade measure, the point of taking average export weights, instead of time-varying weight, in the construction of the country specific commodity price indices, the preference for selecting small economies and finally the choice of the econometric strategies all result to some extent from the need to address endogeneity concerns. We now present the four sources of endogeneity that must be addressed in these analyses.

3.5.4.1 Commodity terms of trade

The identification of terms of trade shocks in explaining real exchange rate fluctuations is not an easy task, as terms of trade are generally not exogenous to the domestic economy. However, there is a component of the terms of trade that is largely considered to be exogenous to small economics. Indeed, commodity prices are set on international markets and commodity terms of trade can reasonably be considered as exogenous, that is $CToT_t \perp \varepsilon_t$. In their review of natural experiments in macroeconomics Fuchs-Schuendeln and Hassan (2016) note that commodity price variations are viewed as quasi-natural experiments for small economies. This assumption of commodity prices' exogeneity explains the development of the commodity currency literature and the construction of commodity terms of trade databases as the one of Gruss and Kebhaj (2019).

3.5.4.2 Terms of trade endogeneity

Although commodity prices can be viewed as exogenous, this is generally not the case of country specific commodity terms of trade. Indeed, commodity terms of trade reflect fluctuations in commodity prices but also variations in the mix/weight of commodity exports. This mix is partially endogenous and can reflect new export and development policies, which are determined at the domestic level.

As a consequence, and to ensure that endogenous supply responses to price changes do not affect the analysis, it is a common practice to build the commodity price indices by taking commodity fixed weights, computed as average commodity weights in total commodity weights over a few years.

What is a "*few years*" is not consensual (3 years, the full sample, mid-window average, etc), but this choice has potentially substantial consequences. Indeed, the mix of commodity exports is not stable over time and this variability can sometimes be extreme. For example, the share of aluminum in Mozambique exports was below 10 percent before 2001 and more than 50 in

2001. By taking the average weight of aluminium over say 20 years we would largely overestimate the weight of aluminium in commodity exports before 2001 and largely underestimate it as from 2001. An alternative solution to the weight endogeneity problem consists in selecting the first main exported commodity (say oil in Saudi Arabia and copper in Chile), but this approach remains subject to large changes as the one discussed above for Mozambique and aluminium.

A visualization of the commodity export basket over time helps in detecting such jumps. Gruss and Kebhaj (2019) propose to complement terms of trade measures based on fixed weights, with an alternative measure where weights are time-varying and based on 3 years rolling averages.

3.5.4.3 Market power

One underlying assumption of the commodity currency literature is that fluctuations of the commodity price indices are exogenously affecting the real exchange rates, in other words, $CToT_t$ is independent of ε_t. This is reasonable as long countries be small enough, compared to the globalized commodity markets. Gruss and Kebhaj (2019) showed that "*the world export market share of individual countries is larger than 40% in only a few food commodities: palm oil (Malaysia), soybeans (US), corn (US), olive oil (Spain), and soybeans oil (Argentina).*" For minerals, the world market shares of Chile, Niger and Australia for copper, uranium and coal, exceed 20%, 30%, 20%, respectively.

To test the market power of these countries, Gruss and Kebhaj (2019) tested the hypothesis that GDP Granger-causes the commodity terms of trade for different group of countries over 1970-2014. They do not reject the null of Granger non-causality and confirm that commodity terms of trade can be taken as exogenous from the perspective of individual countries. This might come as a surprise as the market shares of 20% and more, mentioned above, are quite substantial but two caveat apply here. First, the market shares focus on total exports and not on total production. Second, substitution across similar commodity products mitigate the market power that large commodity exporters have, "*even within the specific markets that they appear to dominate.*" (Chen and Rogoff, 2003).

Still, some (few) studies challenge this view. First, Chen and Lee (2018) studied the impact of market shares on the strength of commodity currencies and found "*that as a country's market power increases, RER reacts less to a given COMP change*". Second, Clements and Fry (2008) considered the case where a group of commodity-exporting countries have combined market power and found that "*spillovers from commodities to currencies contributed less than 1 percent to the volatility of the currency returns, while spillovers from currencies to commodities generally contributed between 2 and 5.2 percent to the commodities*." They concluded that this spillover reflected the endogeneity of commodity prices induced by market power. Neutralizing countries with a potential market power should be included in robustness analyses of commodity currency papers.

3.5.4.4 Omitted variable

Another source of endogeneity may arise from omitted variable. Some macroeconomic variables affect similarly the real exchange rate and the commodity prices. For example, interest rates influence (negatively) the commodity prices and (negatively) the (real) exchange rate of developing countries (see MacDonald and Nagayasu, 2000). Similarly, business cycles are also common determinant. Some studies take these possibilities on board by accounting for unobserved global factors (Bodart et al. 2012) or discuss these potential biases (Chen and Rogoff (2003)). According to Bai et al. (2009)'s approach, these global factors can be modelled by imposing a factor structure on $e_{i,t}$

$$RER_{i,t} = \alpha_i + \beta \, CToT_{i,t} + e_{i,t} \quad (10)$$

$$e_{i,t} = \sum_{r=1}^{R} \lambda_{i,r} \, f_{r,t} + \varepsilon_{i,t} \quad (11)$$

where $f_{r,t}$ is the, potentially non-stationary, r-th latent common factor, $\lambda_{i,r}$ is the loading on factor $f_{r,t}$ and $\varepsilon_{i,t}$ is the idiosyncratic error. Based on this approach, Bodart et al. (2012) showed that the estimations of the elasticity of the real exchange rate to commodity price fluctuations are smaller than those reported in the previous empirical literature.

3.6 Discussion

The commodity currency literature relies on the assumption that commodity prices are exogenous. Price variations are then viewed as quasi-natural experiments (Fuchs-Schuendeln and Hassan (2016)). This assumption should not be taken as granted, as omitted variables and market power reverse causality are legitimate concerns that have been documented. These endogeneity concerns should be carefully discussed and addressed, when needed, by appropriate econometric responses.

Further relevance of using terms of trade measures based on fixed weights should be assessed country by country by checking the stability of the commodity export weights.

We finally note that some recent studies showed that commodity currency exchange rates have surprisingly robust power in predicting global commodity prices, both in-sample and out-of-sample (Chen et al. 2010, but also Groen and Pessenti 2010, Ferraro et al. 2015). However, these findings on reverse causality differ from the commodity currency literature from two standpoints. First, they focus on the short-term dependence and not on the long-term one. Second, these studies rely on nominal exchange rates and not on real exchange rates.

4. Financialization of commodity markets

4.1 Introduction

Speculation in commodity markets is not a new phenomenon. The tulip mania in 1636-7 gave rise to a dramatic rise and collapse of bulb prices that is comparable to the recent booms in oil (2008) or rare earths prices (2010). The recent commodity booms, however, are related to a specific development, referred to as the financialization of commodity markets, namely the large inflows of financial investors who have no commercial interest in the underlying commodities. The diversification power of commodity investments and their equity-like returns, as documented in Erb and Harvey (2006) and Gorton and Rouwenhorst (2006), have attracted a lot of investors, such as hedge funds and investment funds. According to BIS data, the notional value of outstanding OTC commodity derivatives has risen from USD 0.6 trillion in 2000 to USD 14.1 trillion, its peak, in 2008. According to the testimony of Masters (2008), a portfolio manager in a hedge fund active on the oil market, a new class of agents has come to the market and distorted the price discovery process by following a passive index investment.

Many papers addressed the question of assessing and measuring the genuine impact of the financialization. Recent surveys include those of Irwin and Sanders (2011), Cheng and Xiong (2014), Fattouh et al. (2013), Henderson et al. (2015), Bhardwaj et al. (2015) and Main et al. (2018). According to the typology of Haase et al. (2016), the financialization may have an impact on 6 categories of variables: 1) returns, 2) risk premia, 3) spreads (price differentials between long and short dated futures contracts), 4) volatility, 5) spill-over and 6) spot or futures price levels.

As this is the thema of this paper, we focus here on this latter category, that is, spot or futures price levels. This focus variable is probably the key one in the debate on the financialization of commodity markets. Knowing if the financialization contributed to the rise of oil and rice prices in 2008 matters and potentially calls for policy responses.

We consider below different empirical approaches all designed to capture the effect of financialization on commodity prices. We first discuss the direct measures where we explicitly measure the positions held by financial investors. We then discuss indirect measures based on the detection of breaks around 2004. All these measures are unfortunately subject to endogeneity issues that we highlight in the next subsection, together with some identification strategies. We finally present the recent evolutions, which suggest that the presumed effects of financialization decrease.

4.2 How to measure financialization

4.2.1 Direct measures

Few datasets are available to study the evolution of the share of financial commodity investors in the markets. The semi-annual BIS dataset on OTC derivative commodity contracts does not provide a breakdown by types of investors.

The US Commodity Futures Trading Commission (CFTC) on the contrary provides on a weekly basis reports that contribute to identifying different categories of investors. The Disaggregated Commitments of Traders (COT) covers 22 major physical commodity markets and reports the open interest positions by separating traders into the following four categories of traders: Producer/Merchant/Processor/User; Swap Dealers; Managed Money; and Other Reportables. There are mainly two limits to these data. First, the breakdown does not inform on whether positions are taken on a speculation or hedging basis (Fattouh et al. 2013). Second, the rising role of institutional investors is not visible directly as such investors are split into the swap dealers, managed money and other reportables categories.

As a response, the CFTC provides a report since January 2009 called the COT Supplement that covers 13 selected agriculturals with a breakdown now identifying explicitly the so-called Commodity Index Traders (CIT). This dataset has been widely used in the empirical literature and used to infer CIT positions on other commodities (Singleton (2014)), despite the critics on the validity and representativeness of such inferred positions (Irwin and Sanders (2012)).

Other papers go more granular by relying on specific proprietary data, such as Brunetti et al. (2016) who used individual daily positions of large market participants data from CFTC's Large Trader Reporting System.

Finally, few papers rely on alternative data providers, as Henderson et al. (2015) that used commodity-linked notes issued by, and obligations of, financial institutions. Such notes are filed with the U.S. Securities and Exchange Commission (SEC) and made publicly available through the EDGAR database. These notes are typically purchased by non-informed traders and hedged via long positions on futures markets.

4.2.2 Indirect measures

Although financialization relies on the inflow of financial investors, some studies do not use explicit dataset on investors' positions, but rather take 2003/2004 as an implicit break date where financialization takes effect. These papers provide evidence supporting a rise in co-movement within commodity markets and with equity markets by relying on rolling window correlation (Bhardwaj et al., 2015), on variants of dynamic conditional correlation model (Silvennoinen and Thorp, 2013 and Zhang et al., 2017) or on the time-varying explanatory power of multifactor models (Christoffersen et al., 2019).

Whether direct measures dominate indirect measure remains an open question. The direct measures have a richer information set on the time-varying intensity of financial investor pressure. The indirect ones instead isolate from discussions on the relevant direct measures (CIT, swap dealers and/or money managers) capturing financial investors' pressure and by taking the simple, clear, but arbitrary, view of a break in 2004.

4.3 How to measure effects on commodity prices

Financial investors are mainly active on the paper market. Most empirical studies therefore assess the impact of financialization on the futures prices. However, as discussed in Cheng and Xiong (2014), measuring the impact of financialization on futures is an intermediate step, as what ultimately matters is its impact on the spot market. There is then a second strand of literature that studies the mechanisms whereby the paper market (futures prices) impacts the real market (spot prices).

According to Cheng and Xiong (2014), futures prices are related to spot prices via three mechanisms. First, the theory of storage relates the futures and spot prices via an equilibrium relationship, as documented in Basak and Pavolva (2016). Second, the risk sharing mechanism relates the futures and the expected future spot price via risk premia depending on the hedging pressure, as documented Acharya et al. (2013). Third, the informational role of futures markets takes futures prices as signals to guide commodity demand and thus spot prices, as documented in Dimpfl et al., 2017.

What the data providers call spot prices are not always spot prices, but often the nearest maturity futures contracts. Indeed, most spot trades occur over-the-counter and are not reported in harmonized datasets. Moreover, commodity spot prices are subject to substantial heterogeneity in data quality and commodity grades. Spot prices also reflect locations and specific transportation costs.

4.4 Endogeneity concerns

4.4.1 Futures prices and hedging demand

Most studies relating CIT trade positions to commodity prices presume that CIT (demand side) initiate the trades and Granger-cause the futures price rises. However, CIT positions also reflect producers' hedging needs (supply side). We need here an identification strategy designed to identify a CIT demand shock in view to assess the genuine contribution of CIT investors to the price evolution. Cheng et al. (2015) used fluctuations in the VIX to isolate trades initiated by CITs and found a positive correlation between CIT position changes and futures prices. Henderson et al. (2015) used Commodity-linked note (CLN) issuances to similarly identify trade initiated by financial traders. They found that financial traders "*have significantly positive and economically meaningful impacts on commodity futures prices around the pricing dates of the CLNs when the hedge trades are executed and significantly negative price impacts around the determination dates when the hedge trades are unwounded*".

4.4.2 Spot prices and macro-driven boom

If large inflows of institutional investors on commodity markets can affect the commodity futures prices, the reverse is also true. Indeed, rising commodity prices also attract institutional investors. Most papers based on correlation measures are subject to this endogeneity concern.

Tang and Xiong (2012) studied the correlation of non-energy commodity returns with oil returns and propose a solution. They analyze separately the commodities included in the S&P GSCI and DJ-UBSCI (treatment group) and the commodities excluded from these indices (control group). They found that the commodities of the treatment group, which are presumed to be subject to commodity index traders' purchases, had a rise in their correlation with oil returns significantly larger than the one of the commodities in the control group.

As an alternative, Kilian and Murphy (2013) deal with reverse causality by relying on structural VAR modelling and sign restrictions as identification strategy. They use monthly "*the percent* *change in global oil production, a measure of cyclical variation in global real activity, the real price of crude oil, and the change in above-ground global crude oil inventories. The model is identified based on a combination of sign restrictions and bounds on the short-run price elasticities of oil demand and oil supply.*"

4.5 De-financialization

Weekly futures open interest as reported in CFTC's CoT fell by 50% in 2008 but has then recovered and is currently far above its pre-crisis levels. However, all indicators do not support the belief of a constantly rising financialization. The BIS notional value of outstanding OTC commodity derivatives has collapsed from USD 14.1 trillion in 2008 to USD 2.1 trillion in 2019, now stable for more than 5 years. In addition, the composition of the open interest (in terms of producer, swap dealer, money managers, pother reportable) has remained remarkably stable since 2006 (see Figure 9 in Bhardwaj et al., 2015)).

Further, the presumed effects on financialization on inter-commodity correlation and equity-commodity correlations have vanished as documented via simple rolling correlations in Bhardwaj et al. (2015) and via the explanatory power of multi-factor models in Christoffersen et al. (2019). Zhang et al. (2017) explicitly raise the question of "*de-financialization*", measured as correlation between equity market and oil and gas markets. Based on a variance-threshold dynamic correlation model, they conclude that financialization persists since 2008.

4.6 Discussion

The literature on financialization of commodity markets is challenged by the difficulty to identify the exogenous contribution of financial investors to commodity prices. A clear rise of correlation among commodity prices and between commodity and equity prices has been documented by many from 2004 to around 2010, but only few papers were explicitly accounting for reverse causality (rising prices attract investors) or for hedging supply-demand determination (do financial investors go long because commodity hedgers are on the rise). Those that develop original identification strategy (Tang and Xiong (2012), Cheng et al. (2015), Henderson et al. (2015) among others) show that the debate on the persistent effects of financialization ten years after the financial crisis remains open.

5. Conclusion

Commodity prices are at the cross-road of many disciplines and raise a lot of relevant empirical challenges, about the handling of their long-term properties, about their potential exogeneity, viewed by some as quasi-natural experiments, and by their mixed status of financial asset on the one side and of consumption/intermediate good on the other side.

Their properties have given rise to a considerable amount of research on the PSH and it seems we still don't know for sure (cf. Table 1) if the long-term trend of their relative prices is negative or not. We might wonder if the applicability of new time series methodologies has not taken prevalence on the relevance of the research question. New research should better reflect the changing nature of imports, still made of manufactures but also of services and commodities.

The view of commodity prices being exogenous to real exchange rates, seen as quasi-natural experiments from the small economy perspective, is also to be mitigated. As discussed, beside the potential market power of some countries on some specific commodity markets, endogeneity also arises from the influence of common factors such as business cycles and interest rates. New research should reflect these interdependences, via for example structural VAR models or factor models.

Finally, the impact of financialization has been mainly investigated through diverse versions of dynamic conditional correlation models. Only few papers could find a convincing empirical design able to isolate the genuine contribution of financial investors inflows on the commodity prices and volatility, with results generally giving at best a small support to the hypothesis of speculator driven increases. The recent reduction of correlations supports these results and instead support the view of a price boom driven by the real economy.

This paper shows that the PSH, commodity currencies and financialization literatures have surprisingly few connections. To shed some light on these connections is certainly a promising path for research. For example, does the real exchange rate of commodity currency countries decline in the long run, as the PSH suggests? Does the higher commodity price volatility induced by financialization weaken the connection between commodity prices and real exchange rates? Should the PSH encourage financial investors to divest from commodity markets? There is no evidence that the empirical research on commodity prices will decline in the long run.

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