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Consumer sentiments across G7 and BRICS economies: Are they related?

Luis A. Gil-Alana[1,2] · Emmanuel Joel Aikins Abakah[3] · Nieves Carmona-González[2] · Aviral Kumar Tiwari[4,5]

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Abstract

This paper utilizes fractional integration and cointegration techniques to investigate the stochastic properties of the bilateral linkages between the Consumer Sentiment Index (CSI) of eight developed economies, Australia, Canada, France, Germany, Italy, Japan, the UK and the US and five emerging economies comprising Brazil, Russia, India, China and South Africa, for the time period from 15th January 2010 to 15th July 2019. The univariate results support fractional integration with mean reverting behaviour, with many of the series displaying orders of integration in the interval (0, 1), which connotes that shocks to consumer sentiment have significant long-lasting though reverting effects. From the covariate results and testing for cointegration, we found evidence of cointegration for Australia versus Italy, and France versus Italy. For the BRICS, the only evidence of fractional cointegration is found between Russia and India. Some policy implications of the results obtained are also mentioned at the end of the article.

Keywords Consumer sentiment · Persistence · Long memory · Fractional integration

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✉ Luis A. Gil-Alana
alana@unav.es

[1] Faculty of Economics and NCID (ICS), University of Navarra, Pamplona, Spain

[2] Universidad Francisco de Vitoria, Madrid, Spain

[3] University of Cape Coast School of Economics, Cape Coast, Ghana

[4] Rajagiri Business School, Rajagiri Valley Campus, Kochi, India

[5] South Ural State University, Chelyabinsk, Russian Federation

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1 Introduction

Fukuyama (2000) concludes that the confidence of economic agents can be thought of as a social capital since an increase in the confidence level of economic agents positively affects macroeconomic variables. Thus, if the confidence of economic agents increases (decreases), demand and investment are supposed to increase (decrease) and unemployment is supposed to decrease (increase). A number of papers exist in the economic literature, both theoretical and applied, which investigate the effect of consumer confidence upon economic activity (Yew-Kuang 1992; Howrey 2001; Özsagir 2007). These papers conclude that consumer confidence or sentiment which provides insight into how consumers feel about current and future economic conditions, intentions and expectations significantly impact economic growth and activities with some attributing the lack of confidence between economic agents as being one of the main reasons behind the global financial crisis. In recent years, an issue which has aroused much interest in macroeconomics is the analysis of consumer confidence or consumer sentiment. The interest in the consumer attitudes of economic agents stems from the notion that consumer expectations about future macroeconomic conditions are an important driving force of business cycles and future economic sustainability; they tend to determine current consumers economic behaviour (Grybaite and Tvaronavičiene 2008). Expectations were neglected from economic theory for a surprisingly long time, however nowadays they are a component of every macroeconomic model used by central banks. Thus, consumer expectations remain a relevant subject.

Many studies in the economic literature discuss the role of consumers' expectations in various macroeconomic indicators (e.g. Dees and Brinca 2013; Kuzmanovič and Sanfey 2012), measurement methodology issues (e.g., Jonsson and Linden 2009; Wang and Berger-Thomson 2015), determinants of consumer expectations (e.g., Neisingh and Stokman 2013; Medikienė and Dapkus 2018, 2017), consumer sentiments and household consumption (Nguyen and Claus 2013), consumer confidence and stock markets (Jansen and Nahuis 2003), and business cycles and consumer confidence (Taylor and McNabb 2007). Interestingly, even though consumer sentiment analysis has gained considerable attention in the economic literature, there are a limited number of studies on consumer expectations linkages between countries. An existing paper, which comes close to this study examined consumer confidence interconnections between 28 European Union countries using hierarchical cluster analysis methods (Medikienė et al. 2018).

In the present study, we investigate whether future expectations of consumers from developed and emerging economies are integrated or cointegrated using fractional methods to provide a better understanding of how consumer expectations in each country interacts with other countries. Studying consumer sentiment linkages across countries is important because prior literature documents interconnections between countries, which are often fuelled by various economic indicators that exist because of their shared historical background and socio-cultural linkages (Galesi and Lombardi 2009; Zivadinovic and Dumicic and Casni 2009; Ercan and Sayaseng 2016). We argue that this is likely to be the case with regard to the

consumer sentiments or consumer expectations of economic agents. This is because, through global integration, economic agents from countries with similar, historically or culturally determined identities may have similar socio-economic behaviours. We thus examine whether the consumer expectations of economic agents from developed economies with similar determined identities differ from those of emerging economies or if there exist similar economic behaviour patterns across developed and emerging economies.

This study makes a twofold contribution. First, it applies long memory techniques to provide evidence on the stochastic properties (in particular, the degree of persistence) of consumer sentiment indices. Second, it examines their long-run linkages on a bilateral basis using fractional integration and cointegration methods, which is a methodology widely used in both finance and economics (Cheung and Lai 1993a; Baillie and Bollerslev 1994; Baillie 1996; Dueker and Startz 1998; Caporale and Gil-Alana 2002; Gil-Alana et al. 2018; Gil-Alana et al. 2020; etc.). Unlike the majority of earlier studies, this paper adopts a fractional integration and cointegration framework that is much more general than the standard approaches based on the I(0)/I(1) dichotomy since it allows for fractional values of the integration/cointegration parameters, and therefore, it does not impose restrictive assumptions on the dynamic behaviour of the individual series and their linkages. Using data of monthly Consumer Sentiment Index (CSI) of eight developed economies (Australia, Canada, France, Germany, Italy, Japan, the UK and the US) and five emerging economies (Brazil, Russia, India, China and South Africa), our results can be summarized as follows: The univariate work supports the hypotheses of fractional integration and mean reversion with many of the series displaying values of the differencing parameter in the interval (0, 1). The multivariate work indicates evidence of cointegration in some bivariate relationships such as Australia versus Italy, and France versus Italy. For the BRICS, the only evidence of fractional cointegration is found between Russia and India.

The structure of the paper is as follows: Section 2 presents a theoretical background of consumer expectations and a brief literature review of previous studies on linkages among various sets of countries in terms of different economic and financial indicators. Section 3 outlines the methodology used in the paper. Section 4 describes the data and Section 5 the main empirical findings. Section 6 offers some concluding remarks.

2 Literature review

The analysis of consumer confidence is becoming increasingly important. Spending intentions, based on their perception of the economy and their future expectations, are key to predicting, among other things, the evolution of private consumption in countries and, on this basis, to taking appropriate economic policy measures. This is why many studies focus on investigating the relationship between consumer confidence and spending (Mehra and Martins 2003; Dominitz and Manski 2004; Nahuis and Jansen 2004; Bryant and Macri 2005; and Dreger and Kholodilin 2013 among many others).

The study of human behaviour has become important since the Prospect Theory developed by Kahneman and Tversky (1979). Based on empirical evidence, they studied consumer decisions between risky alternatives, connecting psychology with economics, the central focus being the study of human behaviour and decision-making that affect the economy both at microeconomic and macroeconomic levels.

Undoubtedly, consumer confidence has a relationship with the economic fluctuations in the GDP. Matsusaka and Sbordone (1995) analysed the link between consumer confidence and economic fluctuations through regression models, concluding that consumer sentiment accounts for between 13 and 26% of GNP variation. Taylor and McNabb (2007), using cross-correlation statistics and following an approach developed by Den Haan (2000) examined how consumer and business confidence indicators can predict GDP developments during the economic cycle in four European countries (Italy, France, the UK and the Netherlands). Their results showed that both consumers and business confidence indicators are procyclical and generally play a significant role in predicting downturns.

At the country level, Golinelli and Parigi (2004) studied consumer confidence in France, Germany, Italy, the United Kingdom, the United States, Japan, Canada and Australia from the early 1970s to the end of 2002 using a VAR modelling framework. Among their findings they show that the main driving forces of consumer confidence cannot be simply summarised on the basis of macro variables. Building on Beaudry et al. (2011), Stéphane and Güntner (2014), use survey data on consumer sentiment in order to identify the causal effects of confidence shocks on real economic activity in a selection of advanced economies. Starting from a set of closed-economy VAR models, results show that these shocks have a significant and persistent impact on domestic consumption and real GDP.

The existing literature has important limitations. Thus, for example, the data are usually quarterly, other relevant indicators are not taken into account, real-time data are not used, and regression models generally include a very small number of additional variables. Thus, for example, Ludvigson (2004) recommends in the analysis of consumer sentiment the inclusion of determinants of household spending that are suggested by the economic theory and are empirically observable (income, prices, expectations, interest rate, level of indebtedness, among others) since the information provided by consumer confidence predicts a relatively modest amount of additional variation in future consumer spending. In this sense the work of Lahiri et al. (2016) is particularly important. Using a dynamic factor model and a large, real-time, jagged-edge dataset they forecast consumer expenditure with and without consumer confidence, using monthly, quarterly real-time data. Their results state that measures of consumer confidence, in general, make a remarkable and positive contribution to the forecasting of personal consumption expenditure.

Another interesting aspect is the study of how consumer confidence can predict future consumption, productivity and GDP changes. Easaw et al. (2005) seek the relationship between consumer sentiment and household consumption in the United Kingdom and the United States. The analysis concludes that consumer confidence indices predict the consumption of durable goods at home more accurately for the UK than for the US.

Fisher and Huh (2016), used a modelling framework based on I(0) and I(1) variables in a SVAR system of consumer opinion. They modelled the shock associated with the structural equation for the *I*(0) consumer sentiment variable as having a permanent effect on the *I*(1) variables. The contribution of the accumulated consumer sentiment shock to the permanent component of consumption and GDP seems to have substantially increased from 2000 to 2007, a finding they relate to recent work on boom–bust productivity episodes. They then modelled the sentiment shock as with a transitory effect on the *I*(1) variables. Here it appears to have no significant effects and is best thought of as an 'animal spirits' shock unrelated to productivity.[1]

From the above literature it seems that there are no studies dealing with the analysis of the confidence sentiment in the context of fractional integration, an approach that is more flexible and general that the classical one based on integer degrees of differentiation.

3 Empirical methodology

The methodology used is based on the concept of long memory or long range dependence and we use a modelling framework based on fractional integration. According to this, a series might need a number of differences to achieve stationarity I(0), and this number can be a fractional one. That is, we say that a series $\{x_t, t=1, 2, \ldots, T\}$ is integrated of order d, and denoted as $x_t \approx I(d)$ if it can be represented as

$$(1-L)^d x_t = u_t,\ t = 1, ..., \tag{1}$$

where L is the lag operator (i.e., $Lx_t = x_{t-1}$) and u_t is I(0), which is characterized as a covariance (or 2nd order) stationary process where the infinite sum of the autocovariances is finite. That is, u_t can be a white noise process but also a weakly autocorrelated ARMA-type of process.

The estimation of d is crucial in the sense that it allows us to consider a flexible range of alternatives, including anti-persistence (if $d<0$), short memory or I(0) (if $d=0$); stationary long memory ($0<d<0.5$); nonstationary long memory with mean reversion ($0.5 \le d<1$); unit roots ($d=1$) or explosive patterns ($d>1$). We estimate d using the Whittle function as expressed in Dahlhaus (1989) in the frequency domain and use a simple version of the tests of Robinson (1994) to compute confidence intervals of values of d where the null of I(d) behaviour cannot be rejected.

Once the estimation of the univariate analysis has been made, we will move to the multivariate case, examining the possibility of cointegration in a vis-à-vis relationship among the variables. In the bivariate cointegration case, a necessary condition for cointegration is that the two parent series must display the same degree of integration. We test this hypothesis by using Robinson and Yajima (2002) and Hualde's (2013) approaches. Then, we test for cointegration by using the methodology suggested in Cheung and Lai (1993b) and Gil-Alana (2003), which is basically an

[1] Other recent papers dealing with the relationship between consumer sentiment and consumption and spending are El Alaoui et al. (2020), Abosedra, Laopodis and Fakih (2021), Hampson, Gong and Xie (2021).

extension of Engle and Granger's (1987) classical two-step method to the fractional case. Thus, in the first step, we test for the order of integration of the individual series and if the two of them display statistically the same order (say d), we test for cointegration by testing in the second step the order of integration in the residuals from the regression of one of the variables against the other. Thus, if the residuals are I(d-b) with a significant positive b, the two series cointegrate. Critical values are computed numerically in a case by case simulation study in Gil-Alana (2003).

4 Data

Our dataset obtained from Thomson Reuters DataStream consists of monthly Consumer Sentiment Index (CSI) of eight developed economies, thus Australia, Canada, France, Germany, Italy, Japan, the UK and the US and five emerging economies comprising Brazil, Russia, India, China and South Africa for the time period from 15th January 2010 to 15th July 2019.

5 Empirical analysis

Following standard models on parameterization of unit root models (Bhargava 1986; Schmidt and Phillips 1992), we consider the following regression model,

$$y_t = \alpha + \beta t + x_t,\ (1-L)^d x_t = u_t,\ \ t = 1, 2, ..., \tag{2}$$

where y_t refers to the observed time series data, i.e., the consumer sentiment index for each country examined; α and β are the coefficients associated to the intercept (constant) and the linear time trend; d is a real value and u_t is supposed to be I(0). We present the results in terms of the estimated values of d under three set-ups: i) when α and β are assumed to be 0 a priori, that is, imposing no deterministic terms in the regression model (2), ii) with β=0 a priori, that is, allowing for a constant term, and iii) allowing for an intercept and a linear time trend, and estimating α and β freely from the data. Dealing with the disturbance term u_t, we suppose first it is a white noise process; then, we allow for autocorrelation by using a non-parametric spectral approach proposed by Bloomfield (1973) that approximates AR structures, and finally, given the monthly nature of the data, we also consider a seasonal AR(1) process of form:

$$u_t = \varphi u_{t-12} + \varepsilon_t,\ t = 1, 2, ..., \tag{3}$$

where ε_t is supposed to be a white noise process.

Table 1 focuses on the case of uncorrelated (white noise) errors. Starting with the developed economies we observe that the time trend is significant in the cases of France, Germany, Japan and the US, while only an intercept is required for Australia, Canada, Italy and the UK.[2] Apart from that, the most noticeable thing is that all the

[2] We have marked in bold in the table the values of d corresponding to the significant coefficients for the deterministic terms in (2).

Table 1 Estimates of d under no autocorrelation

Series	No terms	An intercept	A time trend
Developed Economies			
Australia	0.94 (0.83, 1.12)	**0.67 (0.58, 0.79)**	0.68 (0.60, 0.80)
Canada	0.94 (0.84, 1.09)	**0.47 (0.37, 0.61)**	0.47 (0.37, 0.61)
France	0.94 (0.82, 1.10)	0.68 (0.59, 0.81)	**0.66 (0.56, 0.80)**
Germany	0.93 (0.82, 1.07)	0.50 (0.43, 0.62)	**0.45 (0.33, 0.62)**
Italy	0.91 (0.80, 1.06)	**0.84 (0.77, 0.94)**	0.83 (0.76, 0.94)
Japan	0.91 (0.79, 1.07)	0.61 (0.53, 0.73)	**0.60 (0.50, 0.73)**
UK	0.90 (0.77, 1.07)	**0.78 (0.71, 0.88)**	0.77 (0.69, 0.88)
US	0.92 (0.80, 1.07)	0.65 (0.60, 0.75)	**0.50 (0.35, 0.69)**
Emerging Economies (BRICS)			
Brazil	0.98 (0.88, 1.13)	**0.86 (0.78, 0.97)**	0.86 (0.77, 0.97)
Russia	0.93 (0.81, 1.09)	**0.52 (0.40, 0.67)**	0.52 (0.40, 0.67)
India	0.88 (0.76, 1.03)	**0.39 (0.30, 0.50)**	0.39 (0.30, 0.51)
China	0.93 (0.80, 1.10)	0.54 (0.48, 0.63)	**0.46 (0.36, 0.59)**
South Africa	0.87 (0.76, 1.02)	0.39 (0.28, 0.56)	**0.39 (0.25, 0.57)**

The values in bold refer to the selected cases according to the deterministic terms. In parenthesis, the 95 confidence bands for the values of d

estimated values of d are constrained between 0 and 1 displaying thus long memory behaviour and a mean reverting pattern. However, for some of the countries, the confidence interval is restricted to the range [0.5 1) implying high levels of persistence, nonstationarity and long lasting effects of shocks. This is the case of Japan (0.60), France (0.66), Australia (0.67) and especially the UK (0.78) and Italy (0.84). For Germany, Canada and the US, however, the values of d are smaller, being around the value 0.5, which is the boundary case between stationarity and nonstationarity.

Panel ii) of Table 1 displays the results for the emerging economies (BRICS). The time trend coefficient is statistically significant for China and South Africa only, and the values of d are also in the (0, 1) long memory interval though nonstationary behaviour ($0.5 \leq d < 1$) is only significant for the case of Brazil (0.86).

Allowing for autocorrelation throughout the model of Bloomfield (1973) (results displayed across Table 2) the time trend coefficient is significant for the same countries as in Table 1 except for Japan which is now insignificant. Focussing on d, the first thing we observe is that the confidence intervals are now wider than in the previous case of white noise errors. Evidence of long memory is found in all countries except for the US where the null of I(0) or short memory behaviour cannot now be rejected. At the other extreme, we observe four countries where the unit root null, i.e., the I(1) hypothesis cannot be rejected. They are Japan (0.81), Italy (0.96) and the UK (0.98) among the developed economies and Brazil (1.10) in the case of the emerging countries. All the remaining countries display values of d within the interval (0, 1), ranging from 0.27 (South Africa) and 0.79 (Australia).

Table 2 Estimates of d under weakly (Bloomfield) autocorrelation

Series	No terms	An intercept	A time trend
Developed Economies			
Australia	0.83 (0.63, 1.12)	**0.79 (0.62, 0.98)**	0.79 (0.64, 0.98)
Canada	0.98 (0.78, 1.28)	**0.49 (0.30, 0.73)**	0.49 (0.30, 0.73)
France	0.92 (0.71, 1.22)	0.68 (0.56, 0.88)	**0.65 (0.50, 0.87)**
Germany	0.95 (0.74, 1.20)	0.50 (0.40, 0.69)	**0.39 (0.15, 0.73)**
Italy	0.87 (0.69, 1.15)	**0.96 (0.85, 1.12)**	0.95 (0.83, 1.12)
Japan	0.81 (0.60, 1.10)	**0.81 (0.61, 1.12)**	0.79 (0.55, 1.12)
UK	0.79 (0.52, 1.08)	**0.98 (0.84, 1.17)**	0.98 (0.84, 1.17)
US	0.95 (0.71, 1.27)	0.63 (0.55, 0.74)	**0.21 (-0.16, 0.60)**
Emerging Economies (BRICS)			
Brazil	0.96 (0.80, 1.23)	**1.10 (0.90, 1.44)**	1.11 (0.92, 1.44)
Russia	0.85 (0.65, 1.13)	**0.58 (0.34, 0.93)**	0.58 (0.33, 0.93)
India	0.84 (0.65, 1.11)	**0.54 (0.37, 0.76)**	0.55 (0.39, 0.76)
China	0.88 (0.66, 1.21)	0.71 (0.58, 0.91)	**0.63 (0.42, 0.89)**
South Africa	0.89 (0.68, 1.18)	0.29 (0.14, 0.51)	**0.27 (0.05, 0.59)**

The values in bold refer to the selected models according to the deterministic terms. The values in parenthesis are the 95% confidence intervals for the values of d

Table 3 Estimates of d under seasonal AR autocorrelation

Series	No terms	An intercept	A time trend
Developed Economies			
Australia	0.94 (0.82, 1.11)	**0.66 (0.56, 0.79)**	0.67 (0.57, 0.79)
Canada	0.94 (0.83, 1.09)	**0.46 (0.35, 0.61)**	0.46 (0.35, 0.61)
France	0.94 (0.82, 1.08)	0.68 (0.58, 0.81)	**0.66 (0.56, 0.81)**
Germany	0.93 (0.82, 1.07)	0.53 (0.44, 0.68)	**0.53 (0.39, 0.71)**
Italy	0.91 (0.80, 1.07)	**0.82 (0.74, 0.93)**	0.81 (0.73, 0.93)
Japan	0.91 (0.79, 1.08)	0.61 (0.53, 0.73)	**0.60 (0.50, 0.73)**
UK	0.90 (0.77, 1.07)	**0.76 (0.68, 0.86)**	0.75 (0.66, 0.86)
US	0.92 (0.80, 1.07)	0.66 (0.60, 0.77)	**0.50 (0.34, 0.70)**
Emerging Economies (BRICS)			
Brazil	0.98 (0.88, 1.13)	**0.85 (0.76, 0.96)**	0.84 (0.75, 0.96)
Russia	0.93 (0.81, 1.09)	**0.52 (0.40, 0.66)**	0.52 (0.40, 0.66)
India	0.88 (0.76, 1.03)	**0.39 (0.30, 0.51)**	0.39 (0.30, 0.51)
China	0.92 (0.80, 1.08)	0.53 (0.46, 0.63)	**0.47 (0.36, 0.60)**
South Africa	0.87 (0.77, 1.02)	0.40 (0.29, 0.56)	**0.39 (0.26, 0.58)**

The values in bold refer to the selected models according to the deterministic terms. The values in parenthesis are the 95% confidence intervals for the values of d

Finally, allowing for a seasonal AR(1) structure, the results are displayed across Table 3. We see that all the estimated values are within the range (0,1). For the developed economies they move between 0.46 (Canada) and 0.82 (Italy), and for the BRICS between 0.39 (India and South Africa) and 0.85 (Brazil). Almost identical

Table 4 Summary of the estimates of d for each series

Country	White noise (1)	Bloomfield (2)	Seasonal AR (3)
Developed Economies			
Australia	0.67 (0.58, 0.79)	0.79 (0.62, 0.98)	0.66 (0.56, 0.79)
Canada	0.47 (0.37, 0.61)	0.49 (0.30, 0.73)	0.46 (0.35, 0.61)
France	0.66 (0.56, 0.80)	0.65 (0.50, 0.87)	0.66 (0.56, 0.81)
Germany	0.45 (0.33, 0.62)	0.39 (0.15, 0.73)	0.53 (0.39, 0.71)
Italy	0.60 (0.50, 0.73)	0.96 (0.85, 1.12)	0.82 (0.74, 0.93)
Japan	0.61 (0.53, 0.73)	0.81 (0.61, 1.12)	0.60 (0.50, 0.73)
UK	0.78 (0.71, 0.88)	0.98 (0.84, 1.17)	0.76 (0.68, 0.86)
US	0.50 (0.35, 0.69)	0.21 (-0.16, 0.60)	0.50 (0.34, 0.70)
Emerging Economies (BRICS)			
Country	White noise (1)	Bloomfield (2)	Seasonal AR (3)
Brazil	0.86 (0.78, 0.97)	1.10 (0.90, 1.44)	0.85 (0.76, 0.96)
Russia	0.52 (0.40, 0.67)	0.58 (0.34, 0.93)	0.52 (0.40, 0.66)
India	0.39 (0.30, 0.50)	0.54 (0.37, 0.76)	0.39 (0.30, 0.51)
China	0.46 (0.36, 0.59)	0.71 (0.58, 0.91)	0.47 (0.36, 0.60)
South Afr	0.39 (0.25, 0.57)	0.29 (0.14, 0.51)	0.39 (0.26, 0.58)

results were obtained when using the logged version of the data. They are reported in the Appendix 1. Using other parametric (Sowell 1992) and semiparametric (Geweke and Porter-Hudak 1983; Phillips and Shimotsu 2005) methods the results were practically identical to those reported here.

Table 4 summarizes the estimates of d for each series and each type of errors. We observe that for the developed countries, the values of d range between 0.21 (the US with Bloomfield) and 0.98 (the UK with Bloomfield errors); for the BRICS, the values are constrained between 0.29 (South Africa) and 1.10 (Brazil).

Based on the results from Table 4 and 5 we display the results of the homogeneity tests using Robinson and Yajima's (2002). Identical results were obtained with the method proposed in Hualde (2013). Starting with the developed countries, we observe that for most of the bivariate relations we cannot reject the null of identical orders of integration. Nevertheless, there are some exceptions such as the cases of Canada, Germany and the US with Italy, where this hypothesis is rejected with Bloomfield (2) and seasonal (3) errors. We also observe divergent orders of integration for Italy and Japan (with seasonal errors), for Australia and the US (with Bloomfield) and for the UK/US with white noise and Bloomfield errors. Finally, the only case where the null hypothesis of equal orders of integration is rejected for the three types of disturbances corresponds to Canada with the UK.

For the developing countries, the null hypothesis of homogeneous orders of integration is rejected in the cases of Brazil and India with South Africa for the three specifications of the error term; also, for Brazil against Russia and China with white noise and seasonal errors, and finally for China with South Africa using Bloomfield.

Table 5 Testing the homogeneity in the orders of integration

Countries	Canada	France	Germany	Italy	Japan	UK	US
Developed Economies							
Australia	(1, 2, 3)	(1, 2, 3)	(1, 2, 3)	(1, 2, 3)	(1, 2, 3)	(1, 2, 3)	(1, 3)
Canada	–-	(1, 2, 3)	(1, 2, 3)	(1)	(1, 2, 3)	Xxxxxx	(1, 2, 3)
France	–-	–-	(1, 2, 3)	(1, 2, 3)	(1, 2, 3)	(1, 2, 3)	(1, 2, 3)
Germany	–-	–-	–-	(1)	(1, 2, 3)	(3)	(1, 2, 3)
Italy	–-	–-	–-	–-	(1, 2)	(1, 2, 3)	(1)
Japan	–-	–-	–-	–-	–-	(1, 2, 3)	(1, 3)
UK	–-	–-	–-	–-	–-	–-	(3)
US	–-	–-	–-	–-	–-	–-	–-
Emerging Economies (BRICS)							
Countries	Russia	India	China	South Africa			
Brazil	(2)	xxxxxx	(2)	xxxxxx			
Russia	—-	(1, 2, 3)	(1, 2, 3)	(1, 2, 3)			
India	—-	—-	(1, 2, 3)	(1, 2, 3)			
China	—-	—-	—-	(1, 3)			
South Africa	—-	—-	—-	—-			

(1) refers to the model with white noise errors; (2) to the model of Bloomfield (1973) and (3) to the seasonal MA(1) model

In all the other cases, we never reject the null of equal orders of integration in the bivariate representation of the series.

Tables 6, 7 and 8 are similar to Table 1, 2 and 3, but referring now to the residuals from the OLS regressions of one variable against the other in all cases except in those that we observe divergent orders of integration for the three types of errors (i.e., Canada-UK, Brazil-India and Brazil-South Africa). Once more we have marked in bold here the selected model for each case according to the deterministic terms, and the summary results in terms of the estimated values of d are reported across Table 9.

Looking at the confidence intervals of the estimated values of d on the residuals and comparing these values with those given in Table 4 for the parent series we conclude that there is no evidence of cointegration of any degree in any of the bivariate representation of the series. These results, however, can be biased due to the methodology used, which based on Robinson (1994) might be biased in favour of the hypothesis of no cointegration.[3] Thus, as a robustness method, we use a second approach, based on the the Hausman test of Marinucci and Robinson (2003) for testing the null hypothesis of no cointegration against the alternative of fractional cointegration.

We use here for the estimation of the differencing parameters the semiparametric "local" Whittle approach of Robinson (1995), using as a bandwidth

[3] The tests of Robinson (1994) impose that the variables in the regression model must be either deterministic or weakly exogenous, which might not be satisfied in our case.

Table 6 Estimates of d in the cointegrating residuals: White noise case

Series	No terms	An intercept	A time trend
Developed Economies			
Australia / Canada	0.63 (0.51, 0.77)	**0.63 (0.54, 0.77)**	0.65 (0.56, 0.77)
Australia / France	0.61 (0.49, 0.78)	**0.59 (0.47, 0.75)**	0.62 (0.52, 0.77)
Australia / Germany	0.66 (0.56, 0.80)	**0.64 (0.55, 0.77)**	0.67 (0.58, 0.78)
Australia / Italy	0.51 (0.39, 0.69)	0.48 (0.37, 0.65)	**0.51 (0.39, 0.67)**
Australia / UK	0.67 (0.57, 0.81)	**0.67 (0.58, 0.79)**	0.68 (0.59, 0.80)
Australia / US	0.66 (0.56, 0.81)	**0.65 (0.56, 0.78)**	0.67 (0.59, 0.79)
Canada / France	0.47 (0.36, 0.61)	**0.47 (0.36, 0.61)**	0.47 (0.36, 0.61)
Canada / Germany	0.47 (0.37, 0.61)	**0.47 (0.37, 0.61)**	0.47 (0.37, 0.61)
Canada / Italy	0.46 (0.36, 0.61)	**0.46 (0.36, 0.61)**	0.46 (0.36, 0.61)
Canada / Japan	0.47 (0.37, 0.61)	**0.47 (0.37, 0.61)**	0.47 (0.37, 0.61)
Canada / US	0.47 (0.37, 0.61)	**0.47 (0.37, 0.61)**	0.47 (0.37, 0.61)
France / Germany	0.55 (0.46, 0.69)	**0.55 (0.46, 0.68)**	0.55 (0.46, 0.68)
France / Italy	0.58 (0.47, 0.73)	**0.57 (0.46, 0.73)**	0.58 (0.46, 0.73)
France / Japan	0.69 (0.60, 0.82)	**0.69 (0.60, 0.82)**	0.68 (0.60, 0.82)
France / UK	0.70 (0.61, 0.83)	**0.70 (0.61, 0.83)**	0.70 (0.61, 0.83)
France / US	0.62 (0.52, 0.78)	**0.61 (0.51, 0.76)**	0.61 (0.51, 0.77)
Germany / Italy	0.57 (0.46, 0.72)	0.49 (0.41, 0.62)	**0.53 (0.43, 0.66)**
Germany / Japan	0.48 (0.37, 0.62)	0.47 (0.37, 0.61)	**0.47 (0.35, 0.61)**
Germany / UK	0.48 (0.35, 0.66)	0.47 (0.35, 0.65)	**0.51 (0.37, 0.68)**
Germany / US	0.43 (0.30, 0.62)	**0.43 (0.30, 0.61)**	0.44 (0.30, 0.62)
Italy / Japan	0.82 (0.75, 0.93)	**0.83 (0.76, 0.92)**	0.83 (0.76, 0.93)
Italy / UK	0.81 (0.74, 0.90)	**0.81 (0.74, 0.89)**	0.80 (0.74, 0.89)
Italy / US	0.79 (0.71, 0.90)	**0.80 (0.72, 0.91)**	0.81 (0.73, 0.91)
Japan / UK	0.59 (0.48, 0.72)	**0.57 (0.46, 0.70)**	0.57 (0.46, 0.72)
Japan / US	0.59 (0.48, 0.72)	**0.57 (0.47, 0.71)**	0.57 (0.47, 0.71)
UK / US	0.70 (0.61, 0.81)	**0.71 (0.63, 0.83)**	0.72 (0.63, 0.84)
Emerging Economies (BRICS)			
Brazil / Russia	0.82 (0.74, 0.93)	0.76 (0.68, 0.88)	**0.76 (0.67, 0.88)**
Brazil / China	0.73 (0.64, 0.84)	**0.68 (0.60, 0.78)**	0.68 (0.60, 0.78)
Russia / India	0.50 (0.38 0.65)	**0.50 (0.39 0.66)**	0.50 (0.39 0.66)
Russia / China	0.51 (0.40, 0.66)	**0.52 (0.40, 0.67)**	0.52 (0.40, 0.67)
Russia / South Africa	0.51 (0.40, 0.67)	**0.52 (0.40, 0.67)**	0.52 (0.40, 0.67)
India / China	0.36 (0.27, 0.47)	**0.36 (0.27, 0.48)**	0.37 (0.28, 0.47)
India / South Africa	0.39 (0.31, 0.51)	**0.39 (0.31, 0.51)**	0.39 (0.31, 0.51)
China / South Africa	0.53 (0.46, 0.63)	**0.53 (0.46, 0.63)**	0.46 (0.37, 0.58)

number $(T)^{0.5}$, widely used in empirical studies.[4] Using other values, the results were fairly similar. The results are reported in Table 10. Columns (1) and (2) refers to the estimates of the individual series, while d indicates the estimates

[4] The tests of Robinson (1994) impose that the variables in the regression model must be either deterministic or weakly exogenous, which might not be satisfied in our case.

Table 7 Estimates of d in the cointegrating residuals: Bloomfield (1973) case

Series	No terms	An intercept	A time trend
Developed Economies			
Australia / Canada	0.59 (0.46, 0.78)	**0.68 (0.52, 0.89)**	0.71 (0.55, 0.89)
Australia / France	0.51 (0.35, 0.76)	**0.52 (0.34, 0.88)**	0.63 (0.45, 0.88)
Australia / Germany	0.66 (0.52, 0.88)	**0.77 (0.59, 0.99)**	0.80 (0.66, 0.99)
Australia / Italy	0.40 (0.20, 0.75)	0.38 (0.20, 0.75)	**0.48 (0.27, 0.79)**
Australia / UK	0.69 (0.55, 0.89)	**0.79 (0.62, 0.98)**	0.79 (0.64, 0.98)
Australia / US	0.67 (0.52, 0.90)	**0.74 (0.56, 0.96)**	0.78 (0.63, 0.96)
Canada / France	0.49 (0.30, 0.75)	**0.49 (0.30, 0.75)**	0.49 (0.30, 0.75)
Canada / Germany	0.49 (0.31, 0.73)	**0.49 (0.31, 0.73)**	0.49 (0.31, 0.73)
Canada / Italy	0.47 (0.30, 0.73)	**0.47 (0.28, 0.74)**	0.47 (0.28, 0.74)
Canada / Japan	0.49 (0.31, 0.73)	**0.49 (0.30, 0.73)**	0.49 (0.30, 0.73)
Canada / US	0.49 (0.30, 0.74)	**0.49 (0.30, 0.74)**	0.49 (0.30, 0.74)
France / Germany	0.57 (0.42, 0.80)	**0.60 (0.43, 0.80)**	0.60 (0.43, 0.80)
France / Italy	0.57 (0.36, 0.83)	**0.55 (0.35, 0.87)**	0.57 (0.35, 0.87)
France / Japan	0.74 (0.59, 0.99)	**0.73 (0.59, 0.96)**	0.73 (0.56, 0.96)
France / UK	0.72 (0.58, 0.94)	**0.72 (0.58, 0.94)**	0.73 (0.58, 0.94)
France / US	0.59 (0.44, 0.85)	**0.58 (0.43, 0.78)**	0.59 (0.43, 0.78)
Germany / Italy	0.60 (0.42, 0.86)	0.53 (0.38, 0.86)	**0.65 (0.45, 0.88)**
Germany / Japan	0.47 (0.29, 0.71)	0.47 (0.29, 0.82)	**0.52 (0.27, 0.85)**
Germany / UK	0.35 (0.16, 0.65)	0.35 (0.16, 0.80)	**0.44 (0.20, 0.84)**
Germany / US	0.28 (0.03, 0.62)	**0.28 (0.03, 0.65)**	0.29 (0.03, 0.70)
Italy / Japan	0.99 (0.86, 1.19)	**0.99 (0.87, 1.16)**	0.99 (0.87, 1.16)
Italy / UK	1.01 (0.89, 1.21)	**1.01 (0.90, 1.19)**	1.01 (0.90, 1.19)
Italy / US	0.93 (0.79, 1.16)	**0.97 (0.83, 1.18)**	0.97 (0.82, 1.17)
Japan / UK	0.75 (0.50, 1.11)	**0.69 (0.47, 1.03)**	0.69 (0.49, 1.03)
Japan / US	0.76 (0.51, 1.10)	**0.70 (0.48, 1.02)**	0.70 (0.48, 1.02)
UK / US	0.77 (0.62, 0.96)	**0.82 (0.64, 1.02)**	0.82 (0.67, 1.02)
Emerging Economies (BRICS)			
Brazil / Russia	0.99 (0.84, 1.28)	**0.93 (0.74, 1.26)**	0.91 (0.71, 1.26)
Brazil / China	1.03 (0.82, 1.44)	**0.99 (0.80, 1.41)**	0.99 (0.80, 1.41)
Russia / India	0.56 (0.31, 0.94)	**0.57 (0.31, 0.93)**	0.57 (0.30, 0.93)
Russia / China	0.58 (0.34, 0.93)	**0.58 (0.34, 0.93)**	0.58 (0.34, 0.94)
Russia / South Africa	0.57 (0.31, 0.92)	**0.56 (0.31, 0.91)**	0.56 (0.31, 0.91)
India / China	0.49 (0.31, 0.71)	**0.49 (0.32, 0.71)**	0.51 (0.36, 0.71)
India / South Africa	0.52 (0.37, 0.74)	**0.55 (0.37, 0.76)**	0.56 (0.39, 0.77)
China / South Africa	0.76 (0.61, 0.96)	**0.76 (0.61, 0.96)**	0.71 (0.53, 0.96)

of the residuals of the regression of one variable against the other. The final two columns refer to the tests of Marinucci and Robinson (2003). We have marked in bold the cases where we found evidence of cointegration by rejecting the null of no cointegration against the two series. We see that for the developed countries, there are only two cases where this hypothesis is satisfied: Australia versus Italy, and France versus Italy. In both cases there is a substantial reduction in the degree of integration, being higher in the former relationship than in the latter. For the BRICS, the only evidence of fractional cointegration is found between

Table 8 Estimates of d in the cointegrating residuals: Seasonal AR(1) case

Series	No terms	An intercept	A time trend
Developed Economies			
Australia / Canada	0.63 (0.52, 0.79)	**0.62 (0.51, 0.76)**	0.63 (0.52, 0.76)
Australia / France	0.61 (0.49, 0.79)	**0.57 (0.46, 0.75)**	0.61 (0.49, 0.76)
Australia / Germany	0.66 (0.56, 0.81)	**0.63 (0.53, 0.82)**	0.65 (0.55, 0.83)
Australia / Italy	0.51 (0.39, 0.69)	0.48 (0.37, 0.62)	**0.49 (0.38, 0.64)**
Australia / UK	0.67 (0.57, 0.82)	**0.66 (0.56, 0.79)**	0.67 (0.57, 0.79)
Australia / US	0.66 (0.56, 0.81)	**0.64 (0.54, 0.77)**	0.65 (0.56, 0.78)
Canada / France	0.46 (0.35, 0.60)	**0.46 (0.35, 0.60)**	0.46 (0.35, 0.60)
Canada / Germany	0.46 (0.35, 0.60)	**0.46 (0.35, 0.60)**	0.46 (0.35, 0.60)
Canada / Italy	0.45 (0.35, 0.60)	**0.45 (0.35, 0.60)**	0.45 (0.35, 0.60)
Canada / Japan	0.46 (0.35, 0.60)	**0.46 (0.35, 0.60)**	0.46 (0.35, 0.60)
Canada / US	0.46 (0.35, 0.60)	**0.46 (0.35, 0.60)**	0.46 (0.35, 0.60)
France / Germany	0.55 (0.45, 0.71)	**0.54 (0.44, 0.68)**	0.54 (0.44, 0.68)
France / Italy	0.58 (0.46, 0.73)	**0.57 (0.45, 0.73)**	0.58 (0.45, 0.73)
France / Japan	0.69 (0.60, 0.82)	**0.69 (0.60, 0.82)**	0.68 (0.59, 0.82)
France / UK	0.70 (0.60, 0.83)	**0.70 (0.60, 0.83)**	0.70 (0.60, 0.83)
France / US	0.63 (0.52 0.78)	**0.61 (0.51 0.76)**	0.61 (0.51 0.76)
Germany / Italy	0.59 (0.47, 0.76)	0.52 (0.42, 0.67)	**0.56 (0.45, 0.71)**
Germany / Japan	0.48 (0.38, 0.64)	0.47 (0.37, 0.62)	**0.47 (0.36, 0.62)**
Germany / UK	0.51 (0.37, 0.70)	0.50 (0.36, 0.68)	**0.54 (0.39, 0.71)**
Germany / US	0.46 (0.32, 0.65)	**0.46 (0.33, 0.64)**	0.47 (0.33, 0.65)
Italy / Japan	0.81 (0.73, 1.91)	**0.82 (0.74, 0.92)**	0.81 (0.73, 0.92)
Italy / UK	0.78 (0.71, 0.88)	**0.78 (0.70, 0.87)**	0.77 (0.70, 0.87)
Italy / US	0.78 (0.70, 0.90)	**0.79 (0.70, 0.90)**	0.79 (0.71, 0.90)
Japan / UK	0.59 (0.48, 0.72)	**0.57 (0.47, 0.71)**	0.57 (0.47, 0.71)
Japan / US	0.59 (0.48, 0.72)	**0.57 (0.46, 0.70)**	0.57 (0.46, 0.71)
UK / US	0.59 (0.48, 0.72)	**0.57 (0.47, 0.71)**	0.57 (0.47, 0.71)
Emerging Economies (BRICS)			
Brazil / Russia	0.81 (0.72, 0.93)	0.74 (0.65, 0.87)	**0.73 (0.63, 0.87)**
Brazil / China	0.72 (0.65, 0.84)	**0.67 (0.59, 0.78)**	0.67 (0.59, 0.78)
Russia / India	0.51 (0.39, 0.61)	**0.51 (0.39, 0.66)**	0.51 (0.39, 0.66)
Russia / China	0.51 (0.40, 0.66)	**0.52 (0.40, 0.66)**	0.52 (0.40, 0.66)
Russia / South Africa	0.51 (0.40, 0.66)	**0.52 (0.40, 0.67)**	0.52 (0.40, 0.67)
India / China	0.37 (0.28, 0.50)	**0.37 (0.28, 0.48)**	0.36 (0.27, 0.48)
India / South Africa	0.40 (0.31, 0.52)	**0.40 (0.31, 0.52)**	0.40 (0.31, 0.52)
China / South Africa	0.52 (0.45, 0.62)	0.52 (0.45, 0.62)	**0.46 (0.37, 0.59)**

Russia and India, obtaining values of d equal to 0.603 and 0.609 for the individual series and 0.419 for the estimated residuals. In all the other cases there is no evidence of cointegration and in some cases even heterogeneous orders of integration are obtained.

Table 9 Summary of the estimates of d for the cointegrating errors

Country	White noise (1)	Bloomfield (2)	Seasonal AR (3)
Developed Economies			
Australia / Canada	0.63 (0.54, 0.77)	0.68 (0.52, 0.89)	0.62 (0.51, 0.76)
Australia / France	0.59 (0.47, 0.75)	0.52 (0.34, 0.88)	0.57 (0.46, 0.75)
Australia / Germany	0.64 (0.55, 0.77)	0.77 (0.59, 0.99)	0.63 (0.53, 0.82)
Australia / Italy	0.51 (0.39, 0.67)	0.48 (0.27, 0.79)	0.49 (0.38, 0.64)
Australia / UK	0.67 (0.58, 0.79)	0.79 (0.62, 0.98)	0.66 (0.56, 0.79)
Australia / US	0.65 (0.56, 0.78)	0.74 (0.56, 0.96)	0.64 (0.54, 0.77)
Canada / France	0.47 (0.36, 0.61)	0.49 (0.30, 0.75)	0.46 (0.35, 0.60)
Canada / Germany	0.47 (0.37, 0.61)	0.49 (0.31, 0.73)	0.46 (0.35, 0.60)
Canada / Italy	0.46 (0.36, 0.61)	0.47 (0.28, 0.74)	0.45 (0.35, 0.60)
Canada / Japan	0.47 (0.37, 0.61)	0.49 (0.30, 0.73)	0.46 (0.35, 0.60)
Canada / US	0.47 (0.37, 0.61)	0.49 (0.30, 0.74)	0.46 (0.35, 0.60)
France / Germany	0.55 (0.46, 0.68)	0.60 (0.43, 0.80)	0.54 (0.44, 0.68)
France / Italy	0.57 (0.46, 0.73)	0.55 (0.35, 0.87)	0.57 (0.45, 0.73)
France / Japan	0.69 (0.60, 0.82)	0.73 (0.59, 0.96)	0.69 (0.60, 0.82)
France / UK	0.70 (0.61, 0.83)	0.72 (0.58, 0.94)	0.70 (0.60, 0.83)
France / US	0.61 (0.51, 0.76)	0.58 (0.43, 0.78)	0.61 (0.51 0.76)
Germany / Italy	0.53 (0.43, 0.66)	0.65 (0.45, 0.88)	0.56 (0.45, 0.71)
Germany / Japan	0.47 (0.35, 0.61)	0.52 (0.27, 0.85)	0.47 (0.36, 0.62)
Germany / UK	0.51 (0.37, 0.68)	0.44 (0.20, 0.84)	0.54 (0.39, 0.71)
Germany / US	0.43 (0.30, 0.61)	0.28 (0.03, 0.65)	0.46 (0.33, 0.64)
Italy / Japan	0.83 (0.76, 0.92)	0.99 (0.87, 1.16)	0.82 (0.74, 0.92)
Italy / UK	0.81 (0.74, 0.89)	1.01 (0.90, 1.19)	0.78 (0.70, 0.87)
Italy / US	0.80 (0.72, 0.91)	0.97 (0.83, 1.18)	0.79 (0.70, 0.90)
Japan / UK	0.57 (0.46, 0.70)	0.69 (0.47, 1.03)	0.57 (0.47, 0.71)
Japan / US	0.57 (0.47, 0.71)	0.70 (0.48, 1.02)	0.57 (0.46, 0.70)
UK / US	0.71 (0.63, 0.83)	0.82 (0.64, 1.02)	0.57 (0.47, 0.71)
Emerging Economies (BRICS)			
Brazil / Russia	0.76 (0.67, 0.88)	0.93 (0.74, 1.26)	0.73 (0.63, 0.87)
Brazil / China	0.68 (0.60, 0.78)	0.99 (0.80, 1.41)	0.67 (0.59, 0.78)
Russia / India	0.50 (0.39 0.66)	0.57 (0.31, 0.93)	0.51 (0.39, 0.66)
Russia / China	0.52 (0.40, 0.67)	0.58 (0.34, 0.93)	0.52 (0.40, 0.66)
Russia / South Africa	0.52 (0.40, 0.67)	0.56 (0.31, 0.91)	0.52 (0.40, 0.67)
India / China	0.36 (0.27, 0.48)	0.49 (0.32, 0.71)	0.37 (0.28, 0.48)
India / South Africa	0.39 (0.31, 0.51)	0.55 (0.37, 0.76)	0.40 (0.31, 0.52)
China / South Africa	0.53 (0.46, 0.63)	0.76 (0.61, 0.96)	0.46 (0.37, 0.59)

Table 10 Testing the null of no cointegration against fractional cointegration

	(1)	(2)	d	H_{10}	H_{20}
Developed Economies					
Australia / Canada	**0.815**	0.605	0.770	0.172	0.770
Australia / France		0.759	0.621	3.200	1.619
Australia / Germany		0.333	xxx	xxx	xxx
Australia / Italy		**1.058**	**0.302**	**22.380***	**48.604***
Australia / UK		1.092	0.813	0.004	6.619
Australia / US		0.595	0.790	0.005	3.223
Canada / France	0.605	0.759	0.502	0.902	5.616
Canada / Germany		0.333	0.492	1.085	2.149
Canada / Italy		1.058	xxx	xxx	xxx
Canada / Japan		0.726	0.502	0.902	4.267
Canada / US		0.595	0.502	0.902	0.735
France / Germany	**0.759**	0.333	xxx	xxx	xxx
France / Italy		**1.058**	**0.585**	**2.574***	**19.026***
France / Japan		0.726	0.838	0.037	0.012
France / UK		1.092	xxx	xxx	xxx
France / US		0.595	0.741	0.027	1.812
Germany / Italy	0.333	1.058	xxx	xxx	xxx
Germany / Japan		0.726	xxx	xxx	xxx
Germany / UK		1.092	xxx	xxx	xxx
Germany / US		0.595	0.264	0.404	9.260
Italy / Japan	1.0.58	0.726	xxx	xxx	xxx
Italy / UK		1.092	1.104	0.179	0.012
Italy / US		0.595	xxx	xxx	xxx
Japan / UK	0.726	1.092	xxx	xxx	xxx
Japan / US		0.595	0.718	0.005	1.286
UK / US	1.092	0.595	xxx	xxx	xxx
Emerging Economies (BRICS)					
	(1)	(2)	d	H_{10}	H_{20}
Brazil / Russia	0.962	0.603	0.678	6.859	0.478
Brazil / China		0.585	xxx	xxx	xxx
Russia / India	**0.603**	**0.609**	**0.419**	**2.879***	**3.069***
Russia / China		0.585	0.476	1.371	1.010
Russia / South Africa		0.362	0.457	1.812	0.767
India / China	0.609	0.585	0.508	0.867	0.504
India / South Africa		0.362	0.542	0.381	2.755
China / South Africa	0.585	0.362	0.722	1.596	11.021

xxx means that the two parent series do not satisfy the hypothesis of equal orders of integration; in bold, evidence of fractional cointegration at the 5% level

6 Conclusion

This paper investigates the stochastic properties of the Consumer Sentiment Index (CSI) of eight developed countries (Australia, Canada, France, Germany, Italy, Japan, the UK and the US) and five emerging economies (Brazil, Russia, India, China and South Africa) using fractional integration and monthly CSI data obtained from DataStream for the period from 15th January 2010 to 15th July 2019. In addition to the above objective, we explore consumer sentiment cointegration to ascertain whether there exists consumer sentiment comovements across the countries studies. On the stochastic properties of the CSI for each country, our results indicate that all the estimated values of d are in the interval (0,1) which indicates evidence of fractional integration and a long memory pattern. This means that shocks are expected to be transitory though with long lasting effects. On cross-country spillovers of consumer sentiment across countries in the developed economies and emerging economies, we find evidence of convergence in the cases of Australia versus Italy and France versus Italy for the developed economies, while for the developing economies we find this evidence of a long run equilibrium relationship only for Russia and India.

The results make it possible to understand how consumer expectations interact in each country and even with other countries, thereby being a useful tool for designing economic policies that place special emphasis on the main component of demand (private consumption) and may improve the adverse effects of potential future crises. Given that Consumer Sentiment Index is considered as a proxy for investor sentiment, the disintegration of consumer sentiment across the majority of countries in our sample further connotes that the magnitude effect of any future financial turmoil is likely to be reduced since the financial turmoil that started in 2007 and the severity of the recession that followed was, to some extent, fuelled by household financial stability which is a key factor affecting economic growth. Consumer sentiment is also linked to stock market returns (Jansen and Nahuis 2003; Chen 2011; Sum 2014) and the results obtained imply a reduction in spillovers across equity markets which drives global market integration. Other lines of research can be conducted on this dataset. For instance, the multivariate approach of the CVAR model (FCVAR) developed by Johansen and Nielsen (2010, 2012) can also be implemented here, and non-linear structures still in the context of fractional integration could also be investigated. Work in these lines of research will be conducted in future papers.

Appendix 1

Table 11 Estimates of d under no autocorrelation

Series	No terms	An intercept	A time trend
Developed Economies			
Australia	0.97 (0.85, 1.13)	**0.67 (0.58, 0.79)**	0.68 (0.59, 0.79)
Canada	0.97 (0.85, 1.12)	**0.47 (0.37, 0.62)**	0.47 (0.37, 0.62)
France	0.97 (0.84, 1.12)	0.68 (0.59, 0.80)	**0.66 (0.56, 0.80)**
Germany	0.97 (0.85, 1.12)	0.51 (0.44, 0.62)	**0.47 (0.34, 0.63)**
Italy	0.95 (0.84, 1.11)	**0.83 (0.76, 0.93)**	0.83 (0.75, 0.93)
Japan	0.97 (0.85, 1.13)	0.62 (0.54, 0.74)	**0.61 (0.51, 0.74)**
UK	0.96 (0.84, 1.12)	**0.78 (0.70, 0.88)**	0.77 (0.69, 0.88)
US	0.96 (0.85, 1.11)	0.64 (0.57, 0.74)	**0.48 (0.33, 0.68)**
Emerging Economies (BRICS)			
Brazil	0.98 (0.87, 1.13)	**0.87 (0.79, 0.97)**	0.87 (0.79, 0.97)
Russia	0.98 (0.86, 1.13)	**0.50 (0.39, 0.65)**	0.50 (0.39, 0.65)
India	0.96 (0.85, 1.12)	**0.37 (0.29, 0.49)**	0.37 (0.29, 0.49)
China	0.97 (0.85, 1.13)	0.55 (0.49, 0.65)	**0.48 (0.38, 0.61)**
South Africa	0.96 (0.84, 1.11)	0.40 (0.29, 0.56)	**0.39 (0.25, 0.58)**

Table 12 Estimates of d under weakly (Bloomfield) autocorrelation

Series	No terms	An intercept	A time trend
Developed Economies			
Australia	0.90 (0.70, 1.16)	**0.78 (0.60, 0.98)**	0.79 (0.64, 0.98)
Canada	0.93 (0.74, 1.21)	**0.46 (0.28, 0.72)**	0.46 (0.28, 0.72)
France	0.93 (0.71, 1.21)	**0.70 (0.58, 0.91)**	0.68 (0.51, 0.91)
Germany	0.93 (0.73, 1.20)	0.50 (0.39, 0.69)	**0.42 (0.15, 0.78)**
Italy	0.91 (0.70, 1.19)	**0.92 (0.82, 1.08)**	0.93 (0.80, 1.08)
Japan	0.89 (0.70, 1.15)	**0.78 (0.61, 1.11)**	0.78 (0.54, 1.11)
UK	0.89 (0.67, 1.16)	**0.95 (0.82, 1.13)**	0.95 (0.80, 1.14)
US	0.94 (0.74, 1.21)	0.60 (0.52, 0.71)	**0.16 (-0.18, 0.53)**
Emerging Economies (BRICS)			
Brazil	0.94 (0.75, 1.18)	**1.15 (0.95, 1.49)**	1.15 (0.95, 1.49)
Russia	0.90 (0.70, 1.17)	**0.57 (0.32, 0.93)**	0.57 (0.31, 0.93)
India	0.90 (0.69, 1.17)	**0.53 (0.35, 0.75)**	0.54 (0.35, 0.75)
China	0.92 (0.72, 1.20)	0.71 (0.59, 0.91)	**0.65 (0.43, 0.90)**
South Africa	0.92 (0.73, 1.20)	0.30 (0.12, 0.52)	**0.25 (0.03, 0.57)**

Table 13 Estimates of d under seasonal AR autocorrelation

Series	No terms	An intercept	A time trend
Developed Economies			
Australia	0.97 (0.85, 1.12)	**0.65 (0.56, 0.78)**	0.66 (0.57, 0.79)
Canada	0.97 (0.85, 1.12)	**0.46 (0.36, 0.61)**	0.46 (0.36, 0.61)
France	0.97 (0.85, 1.13)	0.67 (0.58, 0.80)	**0.66 (0.56, 0.80)**
Germany	0.97 (0.85, 1.12)	0.54 (0.45, 0.70)	**0.55 (0.41, 0.73)**
Italy	0.95 (0.82, 1.11)	**0.81 (0.73, 0.92)**	0.80 (0.73, 0.92)
Japan	0.97 (0.85, 1.13)	0.62 (0.54, 0.74)	**0.61 (0.51, 0.74)**
UK	0.96 (0.84, 1.12)	**0.76 (0.68, 0.87)**	0.75 (0.66, 0.87)
US	0.96 (0.84, 1.11)	0.65 (0.58, 0.76)	**0.49 (0.33, 0.70)**
Emerging Economies (BRICS)			
Brazil	0.98 (0.86, 1.13)	**0.86 (0.77, 0.97)**	0.86 (0.77, 0.97)
Russia	0.98 (0.86, 1.14)	**0.50 (0.39, 0.65)**	0.50 (0.39, 0.65)
India	0.96 (0.84, 1.12)	**0.38 (0.28, 0.50)**	0.38 (0.28, 0.50)
China	0.97 (0.85, 1.12)	0.55 (0.47, 0.64)	**0.48 (0.38, 0.61)**
South Africa	0.96 (0.84, 1.11)	0.40 (0.29, 0.57)	**0.40 (0.26, 0.58)**

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