THE DYNAMICS OF CO-MOVEMENT AND THE ROLE OF UNCERTAINTY AS A DRIVER OF NON-ENERGY COMMODITY PRICES

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The dynamics of co-movement and the role of uncertainty as a driver of non-energy commodity prices.

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ABSTRACT

The purpose of this paper is to improve the empirical evidence on commodity prices in various dimensions. First, we attempt to identify the extent of co-movements in 44 monthly non-energy commodity price series in order to ascertain whether the increase in co-movement is a recent term phenomenon. Second, we attempt to determine the role of uncertainty in determining co-movements between non-energy prices in the short run. We diagnose the overall co-movement using a Dynamic Factor Model estimated by principal components. A Factor-Augmented Vector Autoregressive (FAVAR) approach is used to assess the relationship of fundamentals, financial and uncertainty variables with the co-movement in commodity prices. We find a greater synchronization among raw materials since December 2003. Since that date, uncertainty has played an important role in determining short-run fluctuation in non-energy raw material prices.

Key words: Commodity prices, co-movement, Factor-Augmented Vector Autoregressive models.

JEL classification: E30, F00

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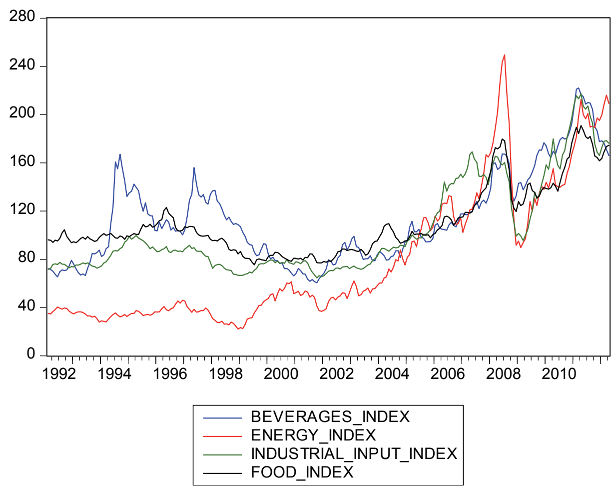
1. Introduction

One interesting characteristic of raw material prices is their tendency to co-move in response to the same shock. Thus, prices which should apparently not be correlated have a common evolution in time. For Pindyck and Rotemberg (1990), there are macroeconomic variables such as the industrial production of developed countries, interest rates and the exchange rate, which influence a large group of raw materials, since they affect the current market as well as the short-term expectation of demand and future supply. Pindyck and Rotemberg (1990) found that commodity prices co-move in “excess” of what can be explained by these variables. This evidence casts a shadow of doubt over the competitive formation of prices in the commodity market, and offers the possibility of studying the role of speculation in this market.

Recently, and in view of the significant increase in raw material prices in the period between 2002 and 2008 (see Figure 1), researchers have once again taken up the debate on the importance of the basic macroeconomic variables which may affect co-movement with regard to the role of speculation by index investors or so-called financialization of commodity markets (see, e.g., Tang and Xiong, 2012, and Irwin, Sanders and Merrin, 2009). An intense debate among scholars started with a Hedge Fund manager´s testimony, that of Mr Michael W. Masters, at the U.S Senate. Masters (2008) drew attention to the fact that the increase in speculative activity in commodity markets, due to the arrivals of new financial traders like Corporate and Government Pension Funds, modified the price determination in the commodity market. According to Masters (2008), assets allocated to commodity indices by institutional investors had risen from 13 billion at the end of 2003 to 260 billion as of March 2008, driving commodity prices higher.

The aim of this paper is to improve the empirical evidence on commodity prices co-movement in two dimensions. First, we attempt to identify the extent of co-movements in 44 monthly non-fuel commodity price series. The aim is to ascertain whether the links among commodity prices, or co-movement, have increased since the end of 2003, as suggested by the promoters of the financialization hypothesis (Tang and Xiong, 2012 and Masters, 2008, among others). Second, we attempt to determine the role of uncertainty as a potential driver of non-energy co-movement in the short run. The extent to which this co-movement is driven by macroeconomic fundamentals and financial variables is also examined, in order to analyze their relative importance. While we evaluate the effect of uncertainty on commodity co-movement, we add to the recent business cycle literature on the macroeconomic effects of “uncertainty” shocks, Bloom (2009), Bernanke (2012) and Baker, Bloom and Davis (2013). Finally, as suggested by Frankel and Rose (2010), there is a lack of empirical evidence with higher frequency data, since most analyses are performed using annual data. The use of monthly data allows us to focus on fluctuations due not only to fundamentals but also to speculative or financial causes.

Figure 1. Indices of Market Prices for Non-fuel (Beverage Food and Industrial Inputs) and Fuel (Energy) Commodities (2005=100, in terms of U.S. dollars).



Source: International Monetary Fund, IMF.

We use monthly non fuel commodity price data from January 1992 until December 2012 and proceed in two steps: First, the use of a large number of commodities and data from different sectors allows us to use a dynamic factor model approach, and to estimate it through principal components. We diagnosed the overall co-movement and confirmed the presence of one latent factor driving commodity prices with the information criteria suggested by Bai and Ng (2002). While we were evaluating the importance of this common factor for the variance of non-fuel commodity prices before and after the end of 2003, we found a very interesting fact: the variance of commodity prices explained by the common factor jumped from 9% in the first sub-period, February 1992- November 2003, to 23% in the second sub-period, December 2003-December 2012. In terms of the scope of the analysis, we present a `before and after´ perspective by looking at two periods; before and after December 2003. Second, we use a Factor-Augmented Vector Autoregressive (FAVAR) approach, proposed by Bernanke, Boivin and Eliasz (2005), to study if the co-movement of commodity prices is affected in the same way by macroeconomic and speculative variables, as well as the uncertainty variable in the two sub-periods.

Our study provides an understanding of the role of uncertainty and fundamental variables that drive co-movement in commodity prices in these two periods. Therefore, our contributions to the literature on co-movement in commodity prices are twofold. First, by considering two different periods, we check whether co-movement is affected in the same way by fundamental and speculative variables, irrespective of time. It is our aim to ascertain which variables; fundamental, financial, or uncertainty, have a greater influence on the common behavior of non-fuel commodity prices.

Second, we examine the importance of market uncertainty in the co-movement of a range of non-fuel commodity prices in the short run. The closest paper to ours is Byrne, Fazio and Fiess (2013), although the two approaches differ in several aspects. First, we focus on the short-term relationship between co-movement in non-fuel commodity prices and macroeconomic and financial variables on a monthly instead of annual basis. The use of higher frequency data allows us to concentrate on speculative price-movements. We believe that the effects of uncertainty over commodity prices are better analyzed in a short-term context. Second, we apply a previously unused variable in the study of uncertainty in commodity prices: The Chicago Board Options Exchange Volatility Index (VIX). This variable reflects a market estimate of future volatility based on the weighted average of the implied volatilities for a wide range of options. Since uncertainty is forward looking, the variable VIX should be a better measure of uncertainty given that it takes into account the expected volatility in the future market. We assess the robustness of our results with other measures such as the Equity Market Uncertainty Index of Baker, Bloom and Davis (2013). Third, we break the sample down in order to analyze the differences along the co-movement before and after the end of 2003 more efficiently. We believe that the sharp increase in the co-movement after that date deserves different treatment in the FAVAR model. Fourth, the estimation properties regarding consistency of the factor co-movement are better accomplished as we do not concentrate on a few commodities, as Byrne et al., (2013) do, but try to include as many as possible. Finally, we add two more variables to the FAVAR, a stock market index variable and the real U.S exchange rate, as they affect co-movement in the short term according to the literature (e.g. Vansteenkiste, 2009, Coleman, 2012). As a robustness check, we also examine the role of inventories in determining short run movements in non-fuel commodity prices.

The rest of the paper is organized as follows. In the next sub section, we briefly review the relevant literature. In section 2 we review the methodology used in the study. In section 3 we illustrate the data. Section 4 shows the main results and robustness checks. The conclusions are presented in section 5.

1.1. Related Literature

We build mainly on the strand of literature that studies co-movements of commodity prices. However, our work is indirectly related to the growing literature on uncertainty and its effects on the economy.

The literature of co-movements in commodity prices is vast and begins with the seminal work of Pindyck and Rotemberg (1990) who state the excess of co-movement hypothesis. The idea put forward by Pindyck and Rotemberg (1990) suggests that prices of a wide range of commodities, at first sight uncorrelated and with cross elasticity of the demand close to zero, follow a common evolution over time. This conclusion is accepted by the authors, after taking into account a series of macroeconomic variables which may affect the set of commodity prices. For Pindyck and Rotemberg (1990), the common behavior of raw material prices should only occur as a reaction to common macroeconomic shocks. They found that the prices of commodities co-move in excess of what can be explained by macroeconomic fundamentals. The evidence of this "excess" of co-movement between different raw material prices implies not only that the price formation is not fully competitive, but also that speculation in commodity markets may play an important role.

In their rejection of the excess of co-movement hypothesis, some authors suggest that macroeconomic variables largely affect the development of raw material prices, e.g Dornbusch (1985), Chu and Morisson (1984), Borenzstein and Reinhart (1994) and Vansteenkiste (2009). Macroeconomic variables in empirical work include those related to demand, such as the production of developed countries, see Borenzstein and Reinhart (1994); variables related to the cost of supplies such as gasoline and fertilizer prices, see Baffes (2007); and variables such as the international situation, which can affect future expectations, and future returns, such as the effective exchange rate, and the US real interest rate, see Calvo (2008)[1]. The relative importance of each one of these determinants, as well as the factor attributed to speculation and uncertainty on the evolution of commodity prices, is currently the subject of debate.

One of the variables to spark controversy is the role of raw material inventories. According to some authors, the scant evidence of stocks proves the small importance of speculation, Krugman (2008). For others, the growth of inventories is not a factor to be taken into account when evaluating speculation. According to Calvo (2008), speculators are not prepared to build up stocks in the face of ever-improving prices.

[1] The link to the state of the business cycle is explored in Camacho and Pérez-Quirós (2013) in a different context using Markov switching models.

Also, if the prices of commodities in the future market are more favorable than those of the present, raw material producers would prefer to postpone their production without it being necessary to accumulate inventory. Authors that have used structural vector autoregressive models to search for dynamic correlations between production, inventories and oil prices are those of Kilian and Murphy (2013) and Juvenal and Petrella (2012).

Financialization of commodity markets is cited as one of the sources of speculation, as well as being one of the main reasons behind the surge of raw material prices after 2003. This process has been described as the substantial increase in the investment in commodities as a form of asset. Tang and Xiong (2012) describe how the low correlation between commodity and market indices could lead to the investors' belief that raw material future investments could reduce portfolio risk. Therefore, after the collapse of the dot-com bubble around 2000 and 2001, various instruments based on commodity indices attracted investment. According to these authors, the financialization of commodity markets not only pushed prices up after 2003, but also permitted a greater correlation among different commodities. For Natanelov, Mackenzie and Huylendbroeck (2011) and Irwin et al. (2009) the proliferation of a variety of instruments such as exchange-traded funds (ETFs) and structured notes (ETNs), which bring together a number of commodities, also influence the co-movement of prices[2]. While one strand of academic research investigations focused on whether financialization is the cause of the upsurge in commodity prices, other authors have concentrated on the correlation between different commodities or between commodities and other financial indicators such as equities. Surveys by Irwin and Sanders (2011) and Fattouh, Kilian and Mahadeva (2013) cast doubts on the idea that the increased speculation in oil future markets in the post-financialization period was a key factor of the upsurge of oil prices. On the other side, Büyüksahin and Robe (2012) and Henderson, Pearson and Wang (2012) present evidence in favor of increasing correlation between equity indexes and commodities due to the presence of hedge funds. In the same line, Hamilton and Wu (2013) document that the risk premium in crude oil futures on average decreased and became more volatile since 2005. Since we divide our sample in December 2003, when index investment started to flow into commodity markets, we seek to add to the literature on the financialization of

[2]In their article, Tang and Xiong (2012) use the end of 2003 and beginning of 2004 as the starting date of the financialization of the commodities.

commodity markets by identifying the impact of energy and stock markets in determining the short run evolution on non-energy price co-movements[3].

Returning to the debate on the explanations of the upsurge in commodity prices, some of the reasons referred to by Zhang and Wei (2010) are the global inflation, the depreciation of the US dollar, and the oil supply manipulation after 2003. For many authors, monetary policy has a major role in determining commodity prices; see, for instance, Hayo, Kutan, Neuenkirch (2012) and Frankel (2008). In fact, with after the financial crisis the world has arrived at a loosely coordinated monetary easing. With such low real interest rates and bond yields, commodities stand out as an alternative asset. Calvo (2008) has also considered the role of the change in the composition of sovereign wealth funds of governments such as China, from highly liquid but low-return assets to those which are more risky, such as commodities. All these are nourished by the low interest rates set by G7 central Banks. Finally, supporters of fundamentals as the major source of price formation in the commodity market, stress the importance of the demand side of the economy. For Krugman (2008) and Hamilton (2009), the fast growth of emerging economies such as China and India has stimulated huge demands for a broad range of commodities in different sectors after 2000. A summary table of the literature that relates to co-movement in non-energy commodities is shown in appendix 1.

Recently, the growing empirical literature on uncertainty has focused on its potential effects on the business cycle (e.g. Bloom 2009, Bernanke 2012, and Baker, Bloom and Davis, 2013). According to Bloom (2009), higher policy uncertainty generates a slowdown in the economy, since businesses tend to postpone investment when there is an uncertain environment. Thus, an uncertainty shock has real effects on output, employment and productivity growth. Uncertainty can also affect risk-premium, which consequently increases the financing cost for entrepreneurs and countries. It may also increase precautionary savings in households, so generating a reduction in aggregate demand.

Despite the apparent importance of uncertainty for the real economy, the literature about its effects on commodity prices is scarce. Beck (1993, 2001) took commodity price volatility in the future market as a measure of risk. He found evidence that expected price risks have a significant effect on price behavior only for storable commodities. For Dixit and Pindyck (1994), uncertainty lowers production because the

[3] Total net assets of commodity exchange trade funds grew 10.000% between 2004 and 2010 according to the Investment Company Institute.

benefit of waiting grows in line with opportunity costs. Uncertainty, therefore, generates an increase in prices. On the contrary, Byrne et al. (2013) empirically found the opposite relationship between risk and commodity prices in a low frequency scenario. This result is in the line with literature that relates uncertainty with equity prices in the short run, suggesting that prices fall precipitously on negative news, and hence induce higher risk premiums (Pástor and Veronesi, 2012, Bekaert, Engstrom and Xing, 2009).

2. Methodology

In the first part of this section, we provide a summary of the factor-augmented vector autoregressive (FAVAR) model that we use in the empirical section. For additional details, see Bernanke et al. (2005).

Dynamic factor models suggest that the information from a large number of time series can be summarized by a relatively small number of common factors plus idiosyncratic noises. In this context, we extract a factor that represents co-movements in commodity prices. We would like to assess for the responses of this factor to common macroeconomic and speculative shocks. For this purpose, we propose a Factor Augmented VAR (FAVAR) approach along the lines of Bernanke et al. (2005). The model is summarized in the following two equations:

$$\begin{bmatrix} F_t \\ X_t \end{bmatrix} = \phi(L) \begin{bmatrix} F_{t-1} \\ X_{t-1} \end{bmatrix} + v_t \qquad (1)$$

$$Y_t = \Lambda F_t + u_t \qquad (2)$$

where $Y_t = (Y_{1t}, \dots, Y_{Nt})'$ is the $N \times 1$ vector of observed variables (non-energy commodity inflations in our case); $\Lambda = (\Lambda_1^{'}, \dots, \Lambda_N^{'})$, $N \times k$, is the factor loading matrix; F_t is the $k \times 1$ vector of common factors; u_t is the $N \times 1$ vector of idiosyncratic noises; X_t is the $p \times 1$ vector of macroeconomic and financial variables; $\phi(L)$ is the $(p+k) \times (p+k)$ matrix of lag polynomials and $v_t \sim (0, \sum_u)$ is the $(p+k) \times 1$ vector of error terms in the FAVAR specification.

Note that in equation (1) the latent variable (F_t) summarizes the developments of non-energy commodity prices. Therefore, the factor, F_t, represents the common pattern of commodities. In this context, equation (1) represents the joint dynamics of (F_t, X_t) and we call it FAVAR.

We cannot directly estimate equation (1) because the factor (F_t) is unobservable; therefore, we need to construct the factor beforehand. In our case, the dynamic factor model given by equation (2) gives the non-energy commodity price inflations (labeled as Y_t) driven by a latent component, F_t, that is common to all series and an idiosyncratic autoregressive component, u_t. The matrix Λ represents the loading of the common factors onto series. Each element of the error or idiosyncratic term, u_t, contains the dynamics specific to each commodity price inflation, although it is assumed to be weakly correlated[4]. The factor may also follow an AR process.

With regard to the estimation, we consider the two-step method favored by Bernanke et al. (2005), in which the factor is extracted prior to estimation of the FAVAR. The use of a large number of commodities allows us to estimate equation (2) through Principal Components. With this we assume that the weighted averages of the idiosyncratic disturbances will converge to zero by the weak law of large numbers, so linear combinations of the observed series are consistent estimators of the common factors. Consistency of the static Principal Components estimator has been demonstrated by Stock and Watson (2002) when both, the number of series N, and the time dimension T converge to infinity. Due to this consistency result, we can treat F_t as observed for inference purposes.

Data definition

In this section we describe the data used in the factor model, related to commodity prices and the macroeconomic and financial variables used in the FAVAR model.

For the dynamic factor analysis we used 44 monthly non-fuel commodity price series from February 1992 to December 2012. Monthly series of commodity prices were obtained from the International Monetary Fund database (IMF IFS). We include in our study the raw materials available in the following categories: food, beverages, agricultural raw material and metals. A summary of the commodities used in this study is shown in Appendix 2.

With regard to the estimation, commodity prices are log differentiated and standardized, prior to the factor extraction by principal components. We follow Stock and Watson (2011) in this respect.

With the FAVAR model we attempt to determine the extent to which this common factor is driven by macroeconomic fundamentals, or whether uncertainty plays a major role. For this purpose we select the most important macroeconomic variables used in the literature of co-movements, and combine them with our proxy for uncertainty. Here we add the role of uncertainty as a potential determinant of commonalities in commodity

[4] For a discussion of dynamic factor models, see for instance, Bai and Ng (2008) and Stock and Watson (2011).

prices. Specifically, we use the Chicago Board Options Exchange Volatility Index (VIX) which reflects a market estimate of future volatility. To the best of the authors' knowledge, this variable has not been used before in the analysis of commodity prices. The rest of the variables are:

- The United States exchange rate. We use the U.S real effective exchange rate. We expect that the decline in the real effective exchange rate may have added momentum to the upward commodities price movement. Some of the papers that take into account this variable are those of Vansteenkiste (2009), Hayo, Kutan and Neuenkirch (2011) and Borenzstein and Reinhart (1994).
- United States real interest rate, proxied in our analysis by the U.S. 3-Month Certificate of Deposit. We expect that lower rates of return on bonds will increase the speculative demand for commodities and hence further raise their price. This variable is used in different studies on commodities (see, e.g., Calvo, 2008, Vansteenkiste, 2009, Borenzstein and Reinhart, 1994 and Frankel, 2008).
- World demand, proxied in our analysis by the World Industrial Production. Borenzstein and Reinhart (1994), Vansteenkiste (2009), Chunrong, Chatrath, and Song (2006), Pindyck and Rotemberg (1990) and Frankel (2008) used this variable.
- Stock Market index. We take for our analysis the MSCI world index, which includes a large collection of world stocks in the developed markets. We use this variable as a proxy of the financial market condition. Coleman (2012) used this variable to explain movements in oil prices.
- Supply shocks are proxied in our study by the Energy Index of the IMF. For some authors such as Krugman (2008), the increase in oil prices may explain the contemporaneous increase in other commodities, such as food products, through two different channels. Firstly, higher energy prices cause upsurges in the production cost which impacts on the rest of commodities final price. Secondly, the increased biofuel demand may lead to a reduction in food supply devoted to final consumption. The last two channels are more associated to long-run effects, since raw material supply is highly inelastic. In the short run, if the financialization hypothesis prevails, we would expect that energy and non-energy prices move in the same direction, given the speculative trade on commodities. The energy index is composed of natural gas and coal, besides oil.

Appendix 3 presents further details regarding the variables we include in the model. Graphical representations of the variables are shown in Appendix 4.

3. Empirical Results

In this section we focus first on the specification of the Dynamic Factor Model and the analysis of the factor and loadings estimated by Principal Components. The estimation of the unobserved factors is the first steps, since we estimate the FAVAR using the two-step approach of Bernanke et al. (2005). Afterwards, we move on to the estimation of the FAVAR for both periods and compare their results.

3.1. Dynamic factor model

We identify the factor structure using the information criteria proposed by Bai and Ng (2002). Bai and Ng (2002) solve the optimization problem that comes from minimizing the sum of squared residuals (divided by NT), defined by:

$$V(k) = (NT)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} (Y_{it} - \lambda_i^k F_t^k)^2, \qquad (5)$$

where the super index *k* in $\lambda_i^k F_t^k$ denotes that *k* factors are considered. To determine the true number of factors, *r* (with $r \leq kmax$), Bai and Ng (2002) formulate the following information criteria:

$$PC(k) = V\left(k, \widehat{F^k}\right) + kg(N,T) \qquad (6)$$

$$IC(k) = \ln\left(V\left(k, \widehat{F^k}\right)\right) + kg(N,T), \qquad (7)$$

where $V\left(k, \widehat{F^k}\right)$ is the average residual variance when *k* factors are assumed and $g(N,T)$ is a penalty function. Bai and Ng (2002) suggested three penalty functions to be taken into account for principal component estimation:

$$g_1(N,T) = \frac{N+T}{NT} \ln\left(\frac{NT}{N+T}\right) \qquad (8)$$

$$g_2(N,T) = \frac{N+T}{NT} \ln(c_{NT}^2) \qquad (9)$$

$$g_3(N,T) = \frac{\ln(c_{NT}^2)}{c_{NT}^2} \qquad (10)$$

where $c_{NT} = min\{\sqrt{N}, \sqrt{T}\}$.

In our case, the three criteria suggest that there is at least one common factor in the data, as can be seen in Table 1. Accordingly, we estimate one common factor, which we name co-movement, for the entire sample and also for the 2 periods we want to analyze: Pre Dec-2003 and Post Dic-2003[5].

[5] Later in the robustness check section, we work further on the number of factors.

Table 1. Number of factors estimated using Bai and Ng(2002) Criteria

Sample	Dates	No. Obs	IC_1	IC_2	IC_3
Full	1992:2-2012:12	251	1	1	1

Notes: All estimates use N=44 series

Figure 3 plots the first estimated common factor, which we call co-movement in non-fuel commodity prices. According to this factor, commodity price booms and busts tend to be relatively short-lived and the factor is more volatile after the end of 2003. Importantly, the variance explained by the factor increases significantly between subsamples. When estimating the first principal component for the period between February 1992 and November 2003, the proportion of the variance of commodity prices explained by the factor is only 9%. However, when the same procedure is performed for the period between December 2003 and December 2012, the variance explained increases to 23%. This would suggest that after the end of 2003, non-fuel commodity prices have become more synchronized or that fluctuations are higher.

Figure 3. Common Factor for Non-Energy Commodity Prices

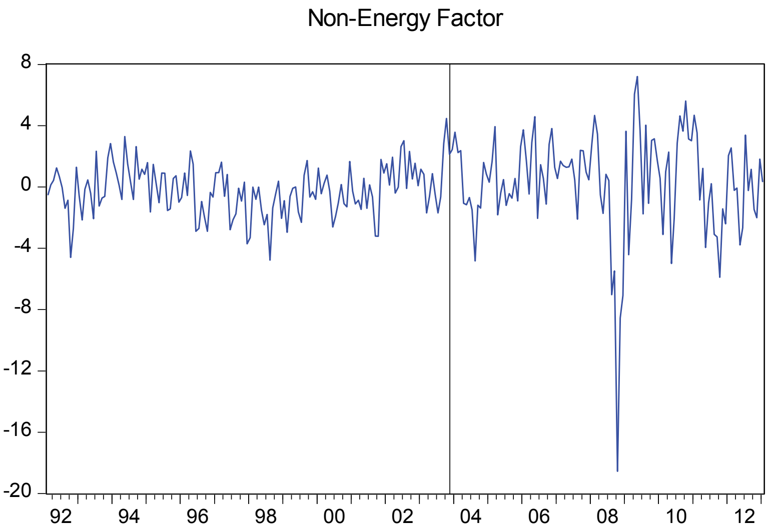


Table 2 shows the commodities with factor loadings above 0.10 in both periods. Although loadings in the first sub-period are larger for four commodities (greater than 0.30), fewer raw material prices reach 0.10 in their factor loading. For the second sub-period, in contrast, there are more commodities with loadings above 0.10. The correlation of the factor with each of the prices is greater in most of the commodities for the second sub-period. It is worth noting that some commodities greatly increased their relationship with the factor in the second period. Sugar, Rubber and Zinc for example, had a factor loading of only 0.123, 0.105 and 0.128, respectively, in the first period. After December 2003, however, their loadings went up to 0.21, for all three commodities. The relationship between commodity prices and the factor increased for edibles in the IMF category of "Food" such as Fish and Beef, and in "Beverages" such as Tea and Coffee. In contrast, the factor loading decreases for "Raw Materials" related to the group Vegetable Oils and Protein Meal.

Table 2. Variance shares explained by the common factor and correlation for the two sub-periods. The table shows only commodities with a loading greater than 0.10.

	1992:2-2003:11	
	Loadings	Average correlation/ Global factor
Soybeans	0.393	0.803
Soybean oil	0.353	0.721
Maize	0.319	0.650
Soybean meal	0.311	0.634
Sunflower/Safflower Oil	0.300	0.612
Barley	0.288	0.588
Wheat	0.229	0.469
Nickel	0.221	0.451
Rapeseed oil	0.195	0.398
Tin	0.186	0.379
Copper	0.175	0.358
Cotton	0.168	0.343
Lead	0.168	0.343
Sugar	0.123	0.252
Zinc	0.128	0.261
Rubber	0.105	0.214

	2003:12-2012:12	
	Loadings	Average correlation/ Global factor
Soybean oil	0.266	0.803
Copper	0.238	0.720
Soybeans	0.231	0.698
Tin	0.225	0.678
Coarse	0.219	0.661
Wool Fine	0.217	0.654
Rubber	0.213	0.645
Sugar	0.211	0.639
Zinc	0.210	0.633
Rapeseed oil	0.209	0.631
Maize	0.207	0.625
Barley	0.207	0.624
Nickel	0.200	0.605
Lead	0.191	0.577
Soybean meal	0.183	0.553
Cotton	0.180	0.544
Wheat	0.168	0.509
Other Milds of Coffee	0.165	0.498
Coffee Robusta	0.158	0.478
Cocoa beans	0.135	0.409
Sawnwood	0.127	0.384
Fish	0.123	0.371
Olive Oil	0.121	0.364
Sugar Free Market	0.120	0.362
Groundnuts	0.117	0.353
Aluminium	0.110	0.332
Sugar US market	0.110	0.331
Uranium	0.103	0.312

Our analysis has highlighted, hitherto, that the increase in commodity communalities started before the financial crisis. In this sense, our work is consistent with the vision of Tang and Xiong (2012), in which the financialization of commodities, starting at the end of 2003, has increased the synchronization among raw material prices.

3.2. The FAVAR model results

In this section, we present the estimation results of the FAVAR model for the two periods analyzed. Our purpose is to examine the short-run linkages among the variables considered in the study. In particular, we are interested in analyzing the impact of uncertainty and macroeconomic and speculative variable shocks on non-fuel commodity prices. We use impulse response functions, as they can trace over time the effects on a variable of an exogenous shock from another variable. Before starting with the results, some final specifications of the model are discussed briefly.

As suggested by Bernanke et al. (2005), we use all variable data in first differences in order to induce stationarity[6]. Moreover, all price series have been transformed into real prices by dividing them by the US Consumer Price Index. We use Generalized Impulse responses for the impulse response function as described by Pesaran and Shin (1998), whose approach does not depend on the VAR ordering.

Our main results in both sub-periods are shown in Figures 4-5 below. Each figure shows the impulse responses of the non-fuel commodity factor to a one-standard deviation shock in all of the macroeconomic and financial variables selected. The FAVAR models, within the first period (pre December 2003) and the second period (post December-2003), were estimated with five and nine lags, respectively, in order to account for residual autocorrelation. The properties of the residuals of the estimated models have been analyzed in Appendix 5, showing the adequacy of the estimated models[7]

[6] The variable VIX is included in first differences; however, our results are robust to the inclusion of this variable in the levels.

[7] A dummy on December 2008 has been included in the FAVAR model for the second period to take into account the world economic crisis. We did not detect heteroscedasticity in the residuals of the FAVAR model.

Figure 4. Accumulated responses of the non-fuel commodity prices to shocks in macroeconomic and financial variables. Period 1992:2/2003:11

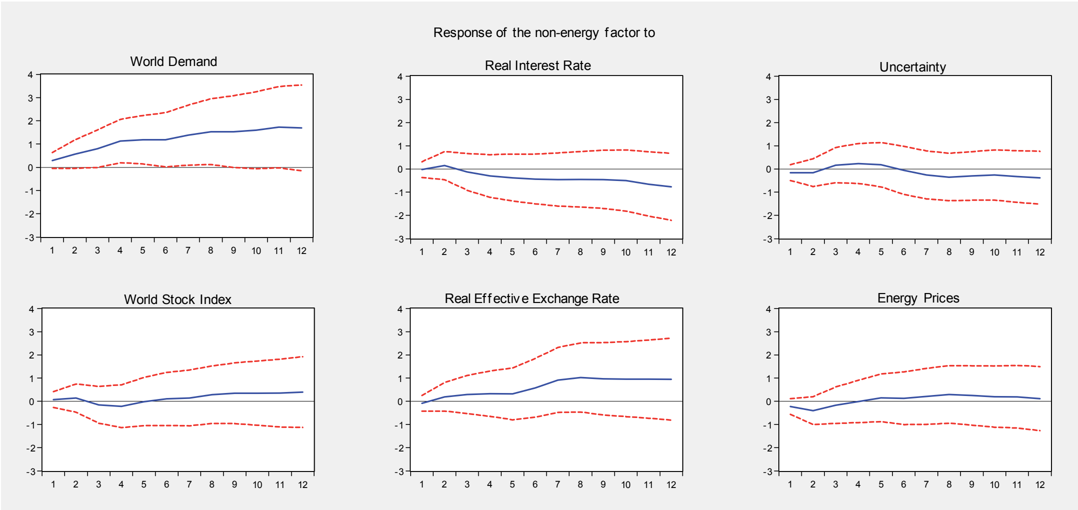
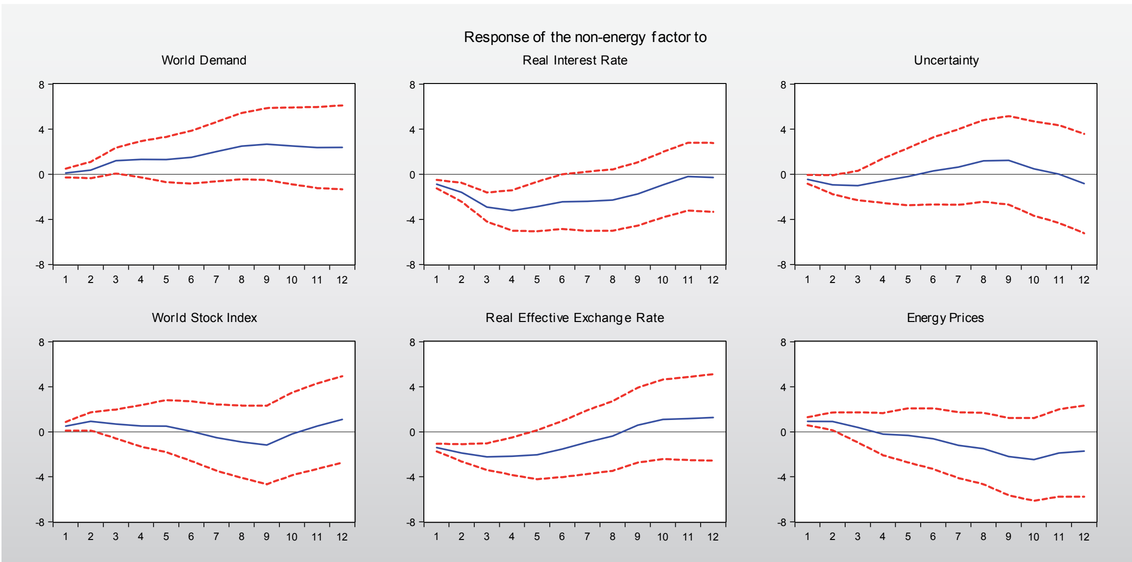


Figure 5 . Accumulated responses of the non-fuel commodity prices to shocks in macroeconomic and financial variables. Period 2003:12/2012:12



For the period prior to December 2003, the impulse response functions of Figure 4 show that the co-movement in non-energy commodities is not significantly affected by most of the macroeconomic or speculative variables. Non-energy co-movement is only affected by a world demand shock. Instead, the shapes of the estimated impulse response functions for the second sub-period are in line with co-movement literature, see Figure 5. We obtain the following results for the second period:

Impulse response estimates from the FAVAR model indicated that a world demand shock seems to show a significant positive rise in non-energy commodity prices. Other macroeconomic variables, such as real interest rate and US real effective exchange rate, have a significant negative impact on non-fuel commodity prices. It seems that in the short run a positive shock in the US interest rate can make investors switch their portfolio investments from risky assets, such as commodity futures, to more conservative ones, such as US treasury bills. The negative effect of a shock on real interest rate on the non-energy factor lasts for 5 months, one of the more lasting effects regarding the impulse response results of the FAVAR model. On the other hand, a real appreciation of the US dollar makes commodity prices fall, as most of the raw material prices are internationally traded and quoted in U.S dollars. The negative effect takes four months to vanish. These results agree with the view that the increase in global demand, the real devaluation of the US dollar and the easy monetary policy of the United States may have added momentum to the upward price movement after 2003.

A supply shock, proxied in this study by energy prices, has an immediate effect on the non-fuel factor. However, this effect tends to disappear after the second month. In this context, we agree with the idea that there is a spillover effect from energy to non-energy commodity prices, enhanced perhaps by the financialization of commodity markets. This effect, however, is less lasting than the shocks in the fundamentals.

With regard to financial variables, we find significant responses of non-fuel commodity prices. Impulse response estimates indicate that a shock in the stock market index is followed by a two month rise in non-fuel commodity prices. These results show the strengthening of cross market linkage after the late 2003[8].

In relation with the effects of uncertainty, that it is proxied by VIX index in the study, we find that an increase in this variable leads to a decrease in the non-energy commodity prices for two months. It seems that uncertainty or volatility in the financial market makes investors more risk averse and bearing. This result is consistent with the ideas of Dixit and Pindyck (1994), in which uncertainty is associated with movements in commodity prices. The negative relationship between our uncertainty variable and

[8] Our findings are in line with the fast-growing literature on co-movements between commodity and equity markets over time –see, e.g., Silvennoinen and Thorp (2013), Stoll and Whaley (2010), Büyüksahin, Haigh and Robe (2010) and Büyüksahin and Robe (2012).

commodity prices are in line with the results of Byrne et al. (2013) who tested it for the long run.

Robustness checks

In this section we propose to check the robustness of our results against other measures of uncertainty, the number of factors within the FAVAR model, and the inclusion of inventories into the model.

For other measures of uncertainty, we use both the “Economic Policy Uncertainty Measure” and the “Equity Uncertainty Measure” constructed by Baker, Bloom, and Davis (2013). The former is constructed taking into account policy-related economic uncertainty with three types of components: frequency of newspaper coverage of policy-related economic uncertainty; federal tax code provisions which were about to expire; and disagreement among economic forecasters. For the second sub-period we took the United States as well as the European Monthly Index of Economic Policy Uncertainty of Baker, Bloom, and Davis (2013). Since the European Monthly Index is constructed from January 1997, we only performed this measure for the second sub-period. The latter, the “Equity Uncertainty Measure” is based on an analysis of news articles in the United States containing terms related to market uncertainty. Robustness checks appear in Appendix 6.

The results for the first sub-period show that all our non-energy commodity price reactions are not significant to any alternative uncertainty measure as is shown in our baseline model. The results for the second sub-period show that a shock in the European Economic Policy Uncertainty as well as in the Equity Uncertainty Measure has a negative impact on the non-energy commodity factor. The United States Policy Uncertainty, however, has no impact on our non-energy factor. From a quantitative standpoint, differences are found for the non-energy responses predicted by the VAR, embedding the European Policy Uncertainty indicator, which predicts much larger responses. However, all non-energy commodity responses are significant and take a sign in line with that suggested by the FAVAR with the VIX indicator.

Although we found only one factor in the whole sample, the determination of the number of factors on the basis of subsamples, say pre-2003 and post-2003 periods, by the information criteria of Bai and Ng (2002) were not so clear, since the third IC pointed the possibility of 2 common factors. To tackle this issue, we evaluate whether our results are robust to two factors. We extract the second component, called a shape component, and re-estimate the FAVAR model, taking into account two factors for the second sub-period. The loadings of the shape component show a separation between metals commodities, with positive loadings, and edibles, with negative loadings. On the other hand, impulse response functions show the same results as our baseline model with regard to the responses of our first factor, called co-movement, to impulses on uncertainty and the rest of the variables. With regard to the shape component, we found significant responses to impulses of energy prices and the real effective exchange rate. Appendix 7 reports the robustness estimations of the FAVAR model with two factors for the second sub-period.

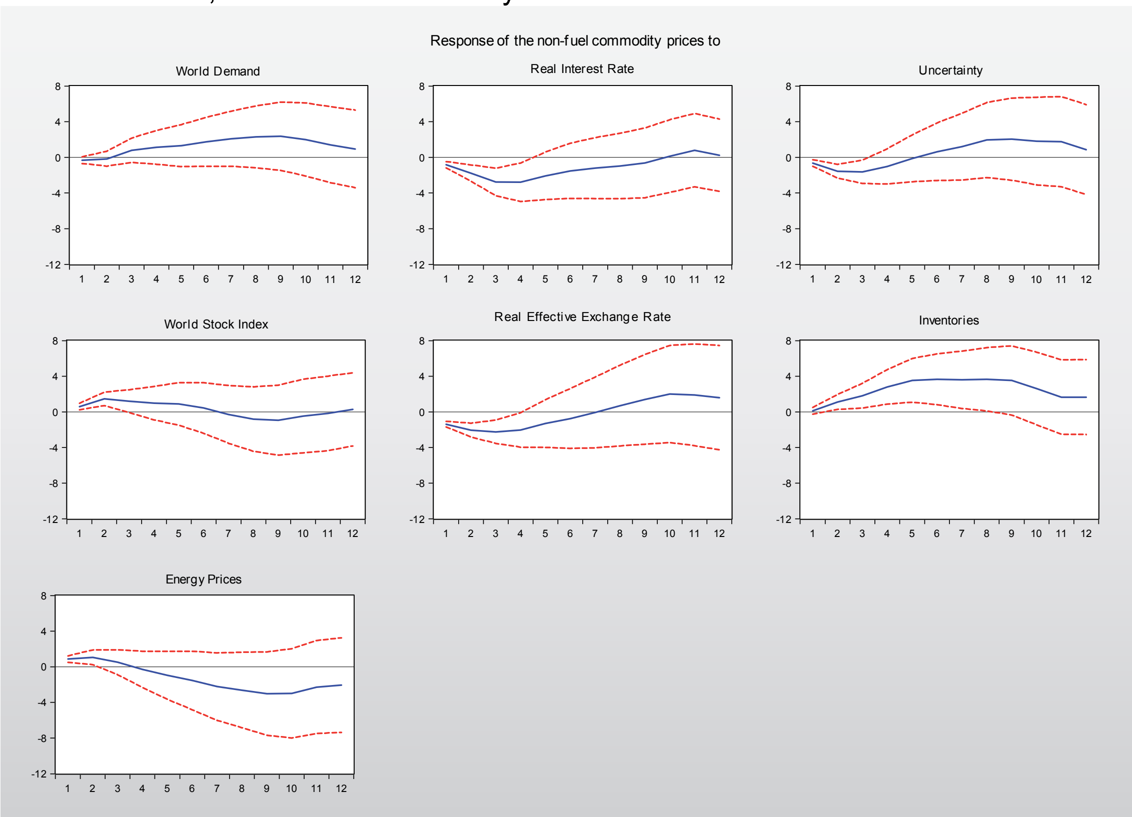
As a final robustness check we include an inventory variable in our FAVAR model[9]. For the second period we found two results: First, our results are robust to the inclusion of inventories. In fact, the FAVAR model with inventories implies a more important role for uncertainty shocks in explaining fluctuations in the co-movement of non-fuel commodity prices than previous estimates. As shown in Figure 6, an increase in uncertainty leads to a decrease in co-movement for three months. Second, inventories have a positive effect on non-fuel commodity prices. Either through fear of future production shortage or speculation (greater expected future prices), inventory accumulation leads to the reduction in the commodities available for current use, causing the non-fuel spot prices to rise.

With respect to the first sub-period, we estimated the FAVAR with inventories of metals due to the lack of a longer data span for the rest of stocks of commodities. Results show little evidence that a positive shock on metal inventories affects the non-fuel commodity factor. This result contrasts with the positive relationship between inventories and non-fuel commodity prices for the second sub-period[10].

[9] We used inventory data of only 12 non fuel commodities due to the lack of information available for the rest of the commodities at a monthly frequency. We use world inventories as far as possible, but substitute with US inventories when these are missing. We describe the inventory data used in Appendix 3. The inventory variable is taken from estimating the first principal component of the 12 non-fuel inventories.

[10] We estimated the FAVAR model for both sub-periods, taking into account the inventories of metals. For the second sub-period we obtained similar results as the model with total inventories. Estimation results are available upon request.

Figure 6 . Accumulated responses of the non-fuel commodity prices to shocks in macroeconomic, financial and inventory variables. Period 2003:12/2012:12

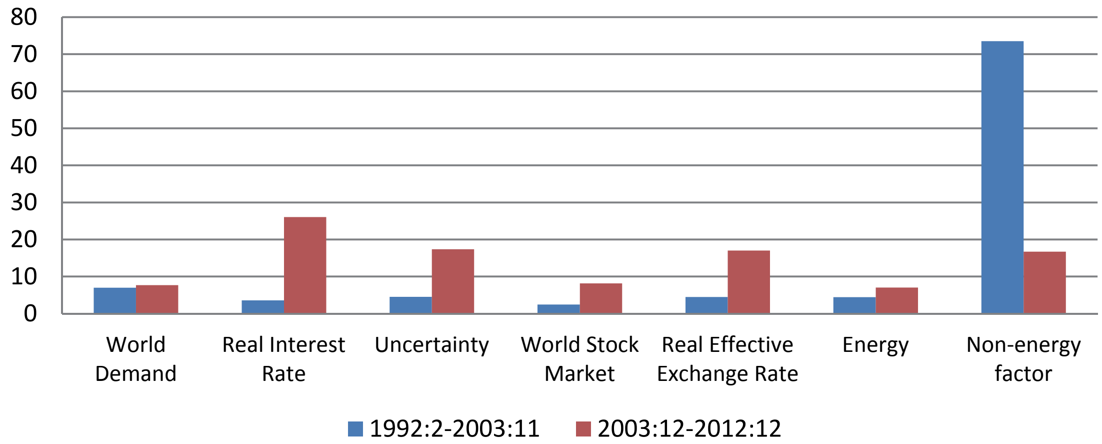


Variance decompositions

Now we present the variance decomposition of the non-energy factor for both sub-periods in order to assess the relative importance of each of the variables in determining the non-energy price co-movement. Yet, variance decomposition requires orthogonality of the inputs if we want the sum of variance due to each component to total 100%. We rely on a given Cholesky decomposition and, therefore, we propose the following ordering of the variables in the VAR: in both of the sub-periods we place our non-energy factor last based on the assumption that non-energy commodity market shocks have no contemporaneous effects on macroeconomic variables. World demand, proxied in our study by global industrial production, is placed first, followed by the interest rate, the volatility variable (VIX), the Stock Market index (MSCI), real effective exchange rate and the IMF energy index. This implies that demand shocks instantaneously affect all equations of the system, which seems logical if we consider that the real exchange rates and interest rates respond greatly to macroeconomic conditions[11].

Figure 6 illustrates the percentage of the forecasting error of the non-energy factor, at a 12 month horizon, that is attributable to a shock in each of the macroeconomic and financial variables of the model.

Figure 6. Variance decomposition of the non-energy factor



Note: Variance decomposition at horizon 12.

In the first sub-period the non-energy factor is the most important driver of its own prices, accounting for more than 70% of price fluctuation. Therefore, inertia has a dominant role in explaining the factor fluctuations. Considering the other variables rather than the lags themselves of the common factor, world demand shocks are the most important driver, explaining up to 7% of non-energy price changes. The rest of the variables shocks account for less than 5% of the non-energy factor.

In the second sub-period the relative importance of the shocks is greatly altered. Real interest rate is now the most important driver of co-movements in non-energy commodity prices, accounting for up to 26% of price fluctuations. The role of a shock in uncertainty is notable, explaining 17.4% of the variation in non-energy prices at all horizons, the second most important driver of the non-energy factor for this period[12]. Shocks in the fundamentals, such as real effective exchange rate and world demand, account for up to 17% and 8%, respectively. Finally, the stock market index variable

[11] As a robustness check for this part, we evaluated a different Cholesky ordering of the variables in the VAR with similar results.

[12] The variance decomposition for horizons up to 24 months, for the non-energy factor is shown in Appendix 8.

and the energy variable explain 8% and 7%, respectively, of the variation in non-energy price fluctuations.

The most important result from this comparison is the increase in the role of uncertainty to explain non-energy fluctuations. The fact that the uncertainty shock accounts for a larger share of variance decomposition of non-energy commodity prices than fundamentals, such as real exchange rate and world demand, emphasizes its importance in determining non-energy spot price formation. Financialization of commodities may make investors much more aware of short term economic developments and may cause passive investors to take collective decisions such as selling risky assets, like commodities, when uncertainty increases, given their correlation with other risky assets.

In conclusion, in the short term, the speculative variables used in our study, which reflect the financial market condition (world stock index) and uncertainty (VIX), significantly affect the real prices of non-fuel commodities in the second period, after the end of 2003. The role of the uncertainty element in determining the joint movements of non-energy prices is noteworthy.

5. Conclusions

This article improves the understanding of the co-movement among non-fuel commodity prices in the short run adding to the literature on financialization of commodity markets. Firstly, we evaluate the magnitude in the co-movement of 44 monthly non-fuel commodity prices from February 1992 to December 2012. Secondly, we break our sample in December 2003, as it is the starting date of unprecedented upsurge of investment into commodity trade funds, in an attempt to ascertain whether co-movement is affected in the same way by fundamentals, financial and speculative variables. We evaluate the responses of non-energy commodities to macroeconomic and financial shocks for these two sub-periods. As we focus in the short run, special attention is paid on the role of the stock market index variable as well as uncertainty in the financial market as a possible determinant of commonalities in commodity prices. With regard to the methodology, we use the FAVAR approach of Bernanke et al. (2005) in order to check what drives co-movement in non-energy commodity prices.

Our results highlight the importance of co-movement between non-fuel commodities that started after the financialization of commodities in late 2003. In this period we found not only an increase in the variance explained by the factor attributable to the co-movement between raw materials, but also the impulse response functions show that variables such as uncertainty and the stock market index significantly impact the factor that relates co-movements in non-energy commodity prices. Moreover, the variance decomposition analysis shows that the uncertainty element plays a larger role in explaining non-energy fluctuation than fundamentals such as the real exchange rate and the real interest rate.

In short, although classical macroeconomic factors of supply and demand are able to explain much of the sharp movements in the short term in non-fuel commodity prices, the growing importance of uncertainty as an important determinant of communalities in non-energy commodities is an element that cannot be ignored.

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Appendix 1. Summary of literature that relates co-movement in commodity prices with fundamental and speculative variables.

	Period of analysis	Commodities (number)	Methodology	Main findings
Studies about co-movement in commodity prices and the role of fundamentals*				
Pindyck and Rotemberg (1990)	1960:04-1985:11	Seven commodities: wheat, cotton, copper, gold, crude oil, lumber, and cocoa	OLS	Commodity prices suffer from excess co-movement. That excess co-movement is evidence of irrational herd behavior. Real interest rate is an important determinant of the demand for inventories and, in turn, of the prices of commodities.
Borenzstein and Reinhart (1994)	1970:Q1-1992:Q3	IMF all commodity index	GLS	Supply variables account more on determining movements in commodity prices than demand factors.
Vansteenkiste (2009)	1957:1-2008:5	32 Non-fuel commodities	DFM with Kalman Filter. IV regressions.	One factor. No excess of co-movement. Macroeconomic variables affect the co-movement in raw material prices.
Chunrong , Chatrath and Song (2006)	1957:Q1-2002:Q3	5 commodities: wheat, barley, corn, oats and soybeans	OLS adn 2SLS	Market indicators such as inventories and crop size, along with macro indicators, explain a large proportion of the price movements, and explain most of the correlations in the raw material prices
Natanelov, Alam, Mackenzie and Huylendbroeck (2011)	1993:11–2001:12(first sample) and 2002:01–2010:02 (second sample)	10 commodities: Crude oil, cocoa, coffee, corn, soybeans, soybean oil, wheat, rice, sugar and gold.	Johansen Cointegration, VECM and Threshold cointegration	Cocoa, wheat and gold prices are cointegrated over the full sample period. Coffee exhibits co-movement with crude oil after the liberalization of the coffee markets. In the case of soybeans, soybean oil and corn especially, the results indicate that biofuel policy has buffered the price relationship between those markets and crude oil futures
Frankel (2008)	1980-2005	23 fuel and non-fuel commodities		Low real interest rate lead to high real commodity prices.

Tang and Xiong (2012)	1:4:1988-10:29:2009	28 commodities with active future contracts traded in the US. (daily futures prices from Pinnacle Data Corp)	Difference-in-Difference	Prices of non-energy commodities became increasingly correlated with oil prices and this trend is significantly more pronounced for commodities in the two popular GSCI and DJUBS indices.
Alquist and Coibion (2013)	1957:1-2013:1	40 commodities	Factor methods and estimate the rotation parameter by GMM	Authors use model predictions to identify the rotation matrix that recovers a set of structural factors. One of them, the level of global economic activity, accounts for about 60-70% of the variance in commodity prices.
Lescaroux (2009)	1980 -2008	51 commodities	Spectral filter and cross-correlations	Raw resources exhibit co-movement. High level of correlation between cycles of commodity prices can be explained to a large extent by common shocks to inventory levels
Studies with FAVAR				
Byrne, Fzio and Fiess (2013)	1900-2008	24 Commodity prices	Panel analysis of non-stationary and idiosyncratic components (PANIC). FAVAR	Risk is negative related with commodity as well as real interest rate
Lombardi, Osbat and Schnatz (2012),	1975:Q1-2008:Q3	15 non-fuel commodities	FAVAR with principal component.	No robust spill-overs from oil to non-oil commodity prices or an impact of the interest rate.

* We focus the literature review in studies with large amount of commodities, especially non-energy commodity prices. We did not include the oil or energy literature

Appendix 2: Non fuel commodities

IMF Category	Commodity
Edibles	
Beverages	Other milds
	Coffee Robusta
	Cocoa beans
	Tea
Food	Soybean oil
	Maize
	Soybean meal
	Wheat
	Rapeseed oil
	Sugar free market
	Bananas
	Fishmeal
	Shrimp
	Swine Meat
	Rice
	Sugar US
	Orange
	Poultry
	Barley
	Beef
	Fish
	Sugar EU
Vegetable Oils and Protein Meal	Soybeans
	Sunflower/Safflower Oil
	Groundnuts
Industrial Inputs	
Metals	Nickel
	Tin
	Zinc
	Copper
	Lead
	Uranium
	Aluminium
Agricultural Row Materials	Wool fine
	Wool
	Cotton
	Rubber
	Hides
	Softwood sawnwood
	Hardwood sawnwood
	Hardwood Logs
	Softwood Logs

Appendix 3: Macroeconomic and Financial Variables

U.S Real Effective Exchange rate. Reer Based on Rel.cp /Index Number /averages /seas. adjusted /Cnt: United States /Source: IMF, Wash

U.S Real interest rate. 3-Month Certificate of Deposit: Secondary Market Rate/Unit: Percent /Cnt: United States /Source: FRED

Energy Index. The Commodity Fuel (energy) Index includes Crude oil (petroleum), Natural Gas, and Coal Price Indices. Base year: 2005/source: IMF.

World Industrial Production. Data from CPB Netherlands Bureau for Economic Policy Analysis

MSCI (Morgan Stanley Capital International) World Index. Data from Bloomberg

VIX index. The Chicago Board Options Exchange Volatility Index reflects a market estimate of future volatility, based on the weighted average of the implied volatilities for a wide range of strikes. 1st & 2nd month expirations are used until 8 days from expiration, then the 2nd and 3rd are used. Source: Bloomberg [BBGID BBG000JW9B77]

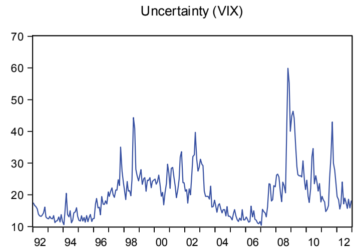
We used the Consumer Price Index to deflate the series that was not in real terms. Specifically: Cpi all Items City Average /Index Number /Base year: 2005 /averages /Cnt: United States /Source: IMF, Wash

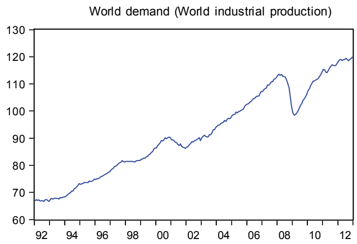
Name and sources of the inventory data used in in the robustness check section

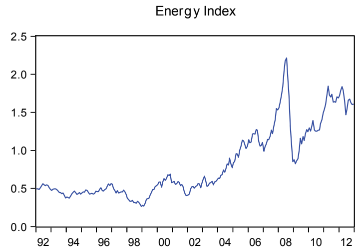
Name	Ubication	Frequency	Period	Source
Wheat Ending Stocks Million Bushels	United States	Monthly	1990:1-2012:12	United States Department of Agriculture, USDA.
Sugar Stocks to Use-Months	Global	Monthly	19977:1-2012:12	F.O. Licht
Aluminium Warehouse Stocks Metric Tonnes	Global	Monthly	1987:7-2012:12	London Metal Exchange
Copper Warehouse Stocks Metric Tonnes	Global	Monthly	1988:10-2012:12	London Metal Exchange
Tin Warehouse Stocks	Global	Monthly	1989:05-2012:12	London Metal Exchange

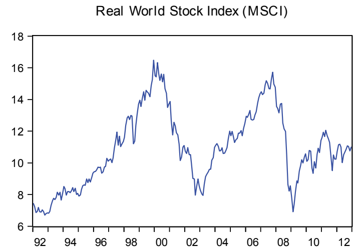
Metric Tonnes				
Zinc Warehouse Stocks Metric Tonnes	Global	Monthly	1988:09-2012:12	London Metal Exchange
Nickel metric tonnes Warehouse Stocks Metric Tonnes	Global	Monthly	1987:7-2012:12	London Metal Exchange
Lead London Metal Exchange Warehouse Stocks Lead Index	Global	Monthly	1987:7-2012:12	London Metal Exchange
Soybean Oil 1000 Tonnes Ending Stocks	United States	Monthly	1994:12-2012:12	USDA
Soybean Meal Ending Stocks 1000 Tonnes	United States	Monthly	1994:12-2012:12	USDA
Cocoa Tonne	Global	Monthly	2002:1-2012:12	NYSE Liffe (London International Financial Futures and Options Exchange)
Corn Ending Stock 1000 Tonnes	United States	Monthly	1994:12-2012:12	USDA
Global Green Coffee Stocks to Use-Days	Global	Monthly	1997:1-2012:12	F.O. Licht

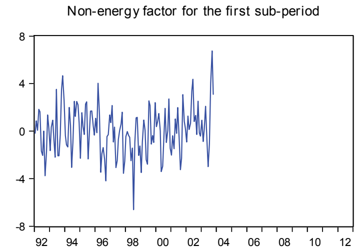
Appendix 4: Graphs of the Macroeconomic and Financial Variables

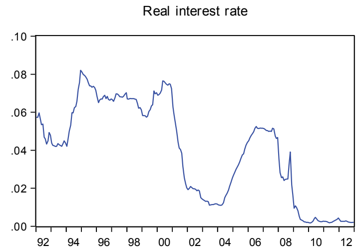


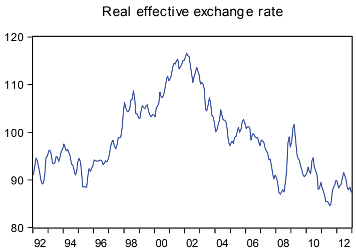


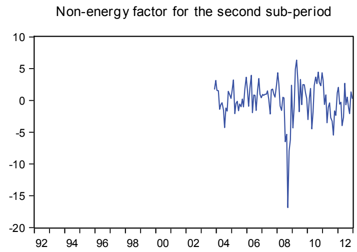












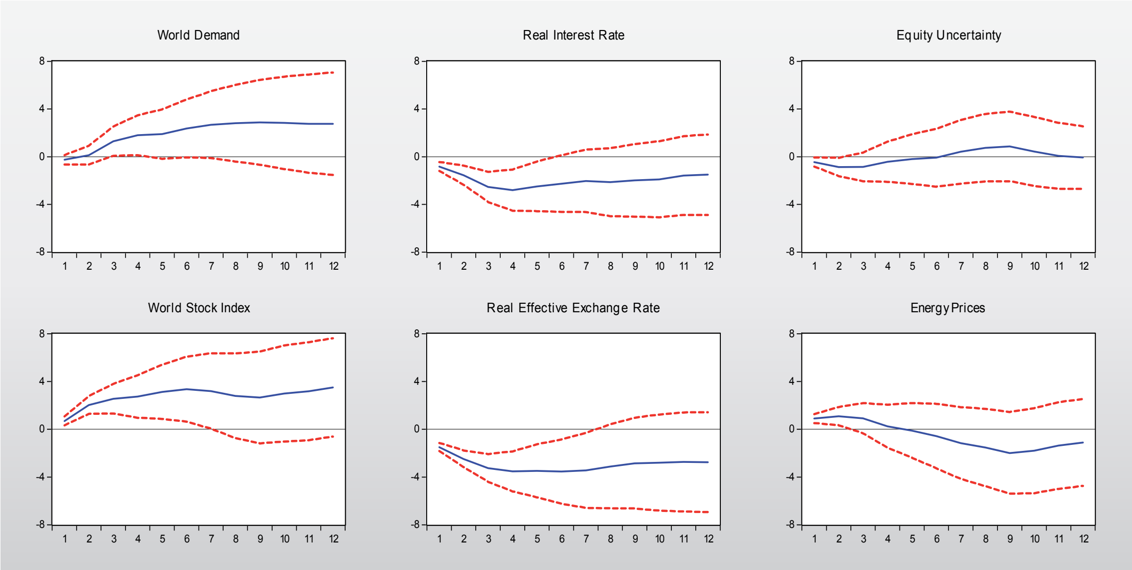
Appendix 5. Residual Autocorrelation analysis of the FAVAR model. Lagrange Multiplier (LM) Test.

1992:2-2003:11	Test	Chi-sq	p-value
	LM(1)	χ^2 (49)= 44.49	0.6563
	LM(2)	χ^2 (49)= 43.09	0.7101
	LM(3)	χ^2 (49)= 51.92	0.3605
	LM(4)	χ^2 (49)= 44.26	0.6651
	LM(5)	χ^2 (49)= 47.06	0.5517
	LM(6)	χ^2 (49)= 39.49	0.8318
	LM(7)	χ^2 (49)= 48.78	0.4820
	LM(8)	χ^2 (49)= 38.42	0.8616
	LM(9)	χ^2 (49)= 50.33	0.4099
	LM(10)	χ^2 (49)= 55.48	0.2436
	LM(11)	χ^2 (49)= 50.33	0.4202
	LM(12)	χ^2 (49)= 35.30	0.9292

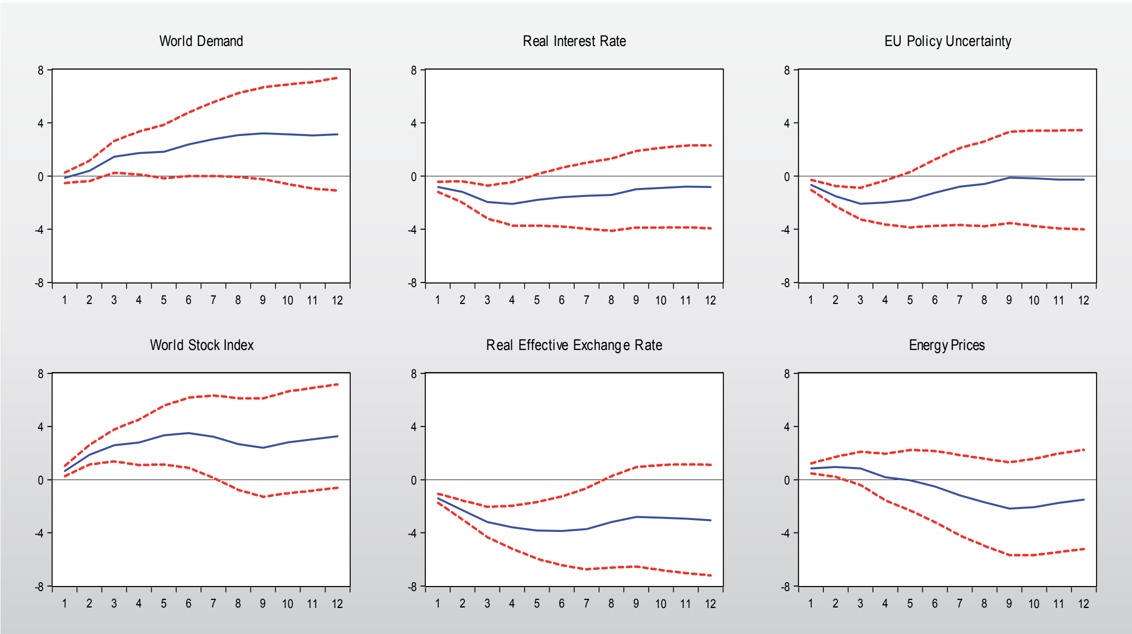
2003:12-2012:11	Test	Chi-sq	p-value
	LM(1)	χ^2 (49)= 55.26	0.2501
	LM(2)	χ^2 (49)= 47.01	0.5539
	LM(3)	χ^2 (49)= 46.43	0.5778
	LM(4)	χ^2 (49)= 50.03	0.4319
	LM(5)	χ^2 (49)= 60.54	0.1247
	LM(6)	χ^2 (49)= 49.22	0.4641
	LM(7)	χ^2 (49)= 39.56	0.8297
	LM(8)	χ^2 (49)= 56.75	0.2085
	LM(9)	χ^2 (49)= 52.42	0.3425
	LM(10)	χ^2 (49)= 43.87	0.6824
	LM(11)	χ^2 (49)= 55.29	0.2490
	LM(12)	χ^2 (49)= 46.67	0.5694

Appendix 6. Robustness checks: different proxies for uncertainty.

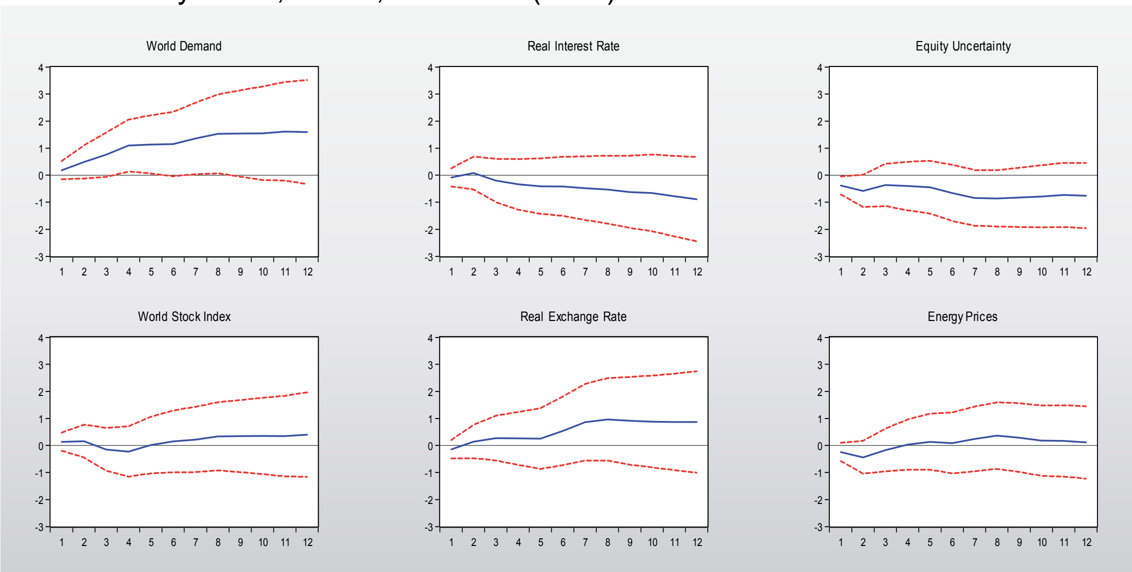
Accumulated responses of the non-fuel commodity prices to shocks in macroeconomic and financial variables. Uncertainty is proxied by the Equity Uncertainty Measure constructed by Baker, Bloom, and Davis (2012). Period 2003:12/2012:12



Accumulated responses of the non-fuel commodity prices to shocks in macroeconomic and financial variables. Uncertainty is proxied by the European Policy Uncertainty Measure constructed by Baker, Bloom, and Davis (2012). Period 2003:12/2012:12

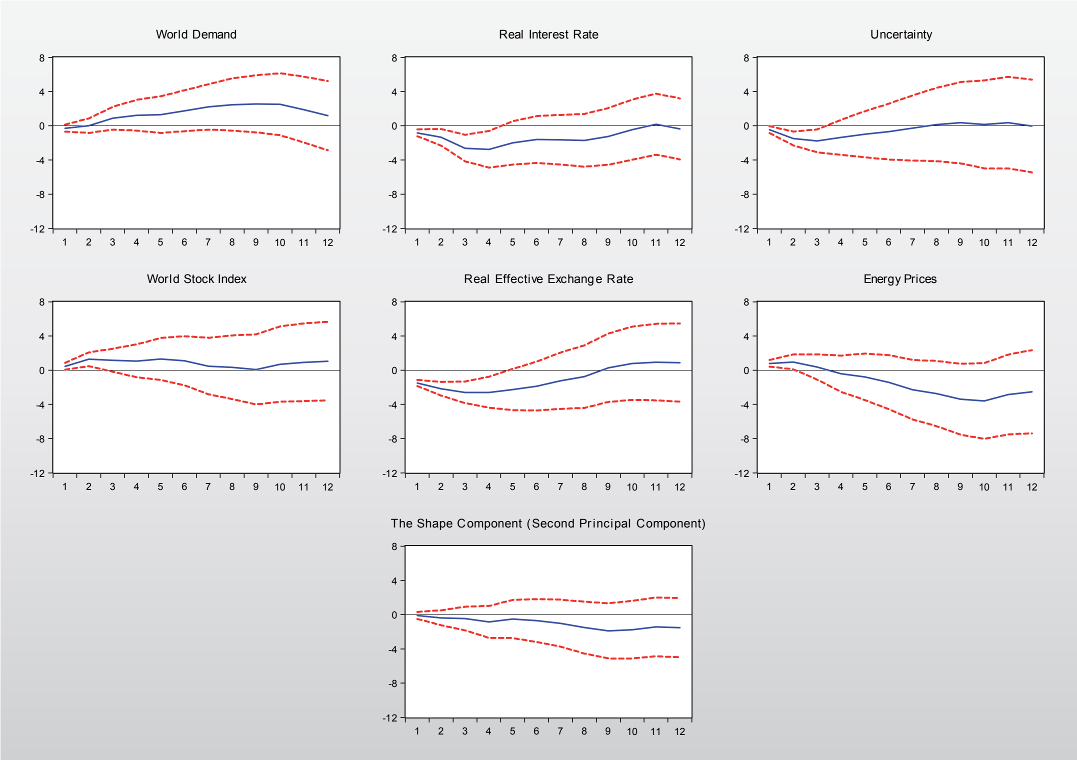


Accumulated responses of the non-fuel commodity prices to shocks in macroeconomic and financial variables. Uncertainty is proxied by the Equity Uncertainty Measure constructed by Baker, Bloom, and Davis (2012). Period 1992:2/2003:11

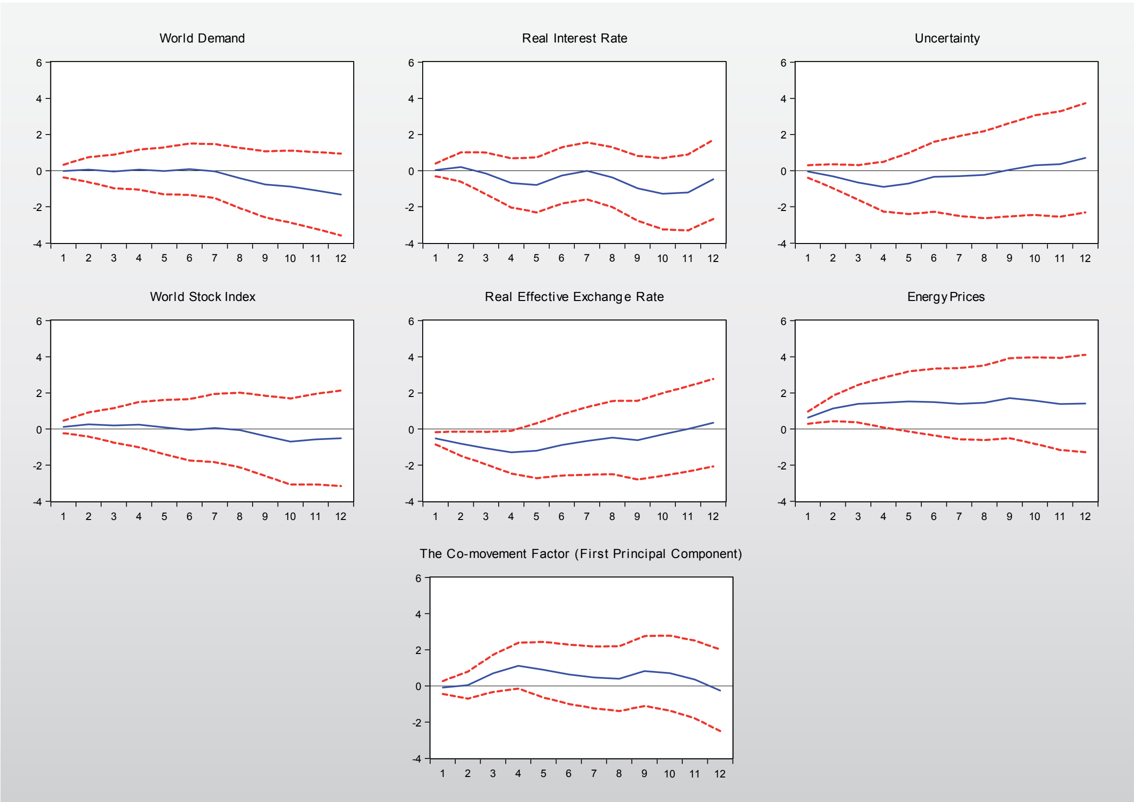


Appendix 7. Robustness checks: FAVAR model with two non-fuel commodity factors.

Accumulated responses of the co-movement factor (first principal component) to shocks in macroeconomic and financial variables.



Accumulated responses of the Shape Component (Second principal component) to shocks in macroeconomic and financial variables.



Appendix 8. Variance Decomposition of the non-energy factor in the FAVAR model.

Horizon	World Demand	Real Interest Rate	Uncertainty	Stock Market Index	Real exchange rate	Energy Index	Non-energy factor
1	0.33	19.93	1.50	2.71	32.44	1.99	41.09
2	1.70	27.26	3.59	2.74	26.63	1.88	36.21
3	10.54	39.21	2.82	2.87	16.93	3.14	24.49
4	9.38	35.22	5.63	4.04	15.21	7.50	23.03
5	8.91	34.78	6.33	6.13	14.51	7.49	21.85
6	8.94	35.19	7.68	5.97	14.13	7.29	20.79
7	10.72	32.53	8.01	7.52	14.57	7.03	19.63
8	12.24	30.31	9.65	7.23	15.50	6.62	18.45
9	11.01	29.12	8.60	8.26	18.01	6.29	18.72
10	9.03	27.90	13.11	8.55	19.12	5.20	17.07
11	8.30	28.13	14.56	8.70	17.41	6.55	16.35
12	7.68	26.05	17.37	8.14	17.02	7.05	16.70
19	7.85	29.17	16.14	10.93	15.89	5.96	14.06
20	7.92	28.89	16.25	11.09	15.87	5.96	14.03
24	8.09	29.33	15.00	11.17	17.34	6.34	12.71