MultibreakeR: A multivariate break test in R

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Abstract

This paper studies the surge of investment tracking commodity futures indices in December 2003. Before 2004, the roll period generated average cumulative abnormal price changes amounting to 115 bps for the nearby contract and 146 bps for the first deferred contract.

Keywords: time series, break test, multivariate break tests.

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1. Introduction

This paper examines

The emergence of CITs induces a change in the supply/demand of nearby and first deferred contracts, which can be analyzed theoretically through the lens of several models.

Our empirical analysis proceeds in three steps. First, we examine whether a structural break simultaneously affects the CITs' market participation in the 27 SP-GSCI components during the 1999—2010 period. Using the Bai, Lumsdaine, and Stock (1998) algorithm. We find a common break in the proportions of open interest (OI) resulting from index investment in the nearby contracts. This break occurs in December 2003 and is statistically significant at the 1% level. It is identical to that retained in Boons, Roon *de*, and Szymanowska (2014). However, it occurs five years before the one identified by Hamilton and Wu (2015) on WTI crude oil futures and three years after the one used by Mou (2011). This date is not affected when we restrict the analysis to the 19 SP-GSCI contracts under the CFTC supervision. As an alternative investment index proxy, we use the market share of the long commercial positions (SCL) that include swap dealers and CITs. The break occurs a month before, in November 2003. We also examine six CFTC contracts that are not components of a commodity index. Reassuringly, we find no break in the 2003–2004 period. Finally, we show that the break does not overlap with the staggered introduction of electronically traded contracts from August 2006 to October 2008.

This paper contributes to the literature in several ways. First, we date the financialization using a statistical method instead of anecdotal evidence.

The remainder of the paper is organized as follows. Section 2 presents the hypothesis development in the context of the existing literature. Section 3 provides details on the data and the methodology. Section 4 reports the empirical results, and their robustness is discussed. Section 5 concludes.

2. Prior literature and hypotheses development

Following the Master's hearing before the U.S. Senate, several articles examine the economic consequences of the financialization and when they materialize. However, previous research diverges on its starting date.

2.1. Dating the financialization

The first strand of literature uses ad-hoc, visual, or indirect evidence to date the financialization. Sanders and Irwin (2011), Basak and Pavlova (2016), Boons et al. (2014), and

Buyuksahin, Haigh, Harris, Overdahl, and Robe (2009) date the financialization around 2003—2004. Hamilton and Wu (2014) in 2005. Mou (2011) shows that front-running the "SP-GSCI roll" generates abnormal returns as early as 1999. The second strand of literature uncovers a progressive rise in different variables that cause (amount of index investment) or through which the financialization materializes (correlation between commodities and stock returns or excess correlation in indexed commodities). Buyuksahin and Robe (2014) report that the correlation between the SP-GSCI daily price changes and SP-500 daily returns rises during the 2004-–2010 period, Adams and Gluck (2015) determine statistically the break date (September 2008). Tang and Xiong (2012) demonstrate that prices of non-energy commodity futures have become increasingly correlated with oil prices after 2004. Similarly, Stoll and Whaley (2010) notice that agricultural futures do not converge to their spot prices during the 2006—2009 period.

Masters (2008) shows that CITs' investment in the total OI changed dramatically from 1998 to 2008. This ratio is a natural candidate for a break caused by index investors. As a result, we should observe a permanent change simultaneously affecting CITs market shares of the SP-GSCI components. Conversely, no break should be observed for the remaining futures contracts.

Hypothesis 1. *The shares of index investment in the total OI of SP-GSCI components (SCIT) show a common break during the 1999-–2010 period.*

As an alternative proxy, we use the proportion of the "long commercials" over total OI since swap dealers and CITs are classified as "commercials" in the legacy CFTC reports. If CITs become important players after the financialization, the share of "long commercials" in total OI (SCL) should increase sharply. This aggregate is interesting because it is also observable for contracts that are not in any index. Therefore, we should not find any common break for non-SP-GSCI contracts. Put differently, we use the group of CFTC contracts that are not components of indices as counterfactuals.

Raman, Robe, and Yadav (2017) state that the "financialization" of commodities comprises three main players: a) commodity index traders ("CITs"), known as "massive passives", b) managed money traders (hedge funds) that are active in multiple asset classes, and c) institutional financial intraday traders after the inception of electronic trading. They show that electronic trading decreases the variance of the pricing error, narrows the bid-ask spread, and improves market depth for the WTI contract. To make sure that CAPCs are not driven by electronic trading instead of the financialization (confounding effect), our hypothesis is as follows,

Hypothesis 2. *CAPCs are affected by the financialization but remain unaffected by the inception of electronic trading.*

3. Data and Methodology

3.1. Dating the financialization

Since 1986, the CFTC has provided the weekly "Commitment of Traders" (COT) report that summarizes "commercials" long and short positions, and long, short, and spreading positions of "non-commercials" categories for U.S. futures contracts.[1] In 2006, the CFTC revised these categories. The "supplemental" (SCOT) report was added for contracts having at least 20 active trader positions above a pre-defined threshold. It was followed by the "disaggregated" (DCOT) report because most swap dealers were classified as "commercials" when, in fact, they were CITs. Despite their non-speculative role, they dedicate a large part of their activity to hedge indices-related positions.[2] The disaggregated report splits the original categories of "commercials" and "non-commercials" into hedgers, swap dealers, managed money, and other "reportables". The supplemental report refers to 13 agricultural futures contracts. The positions reported in the aforementioned categories, managed for commodity investment vehicles (*e.g.* ETFs, ETNs, and mutual funds), are aggregated in a specific category (CIT). From August 2006, the index investment is directly observable from the CFTC reports.

To estimate the share of index investment in the total open interest, we start with the total index investment in the Crude oil WTI contract, which is available in the CFTC special report from 2000 to 2010. The index weights are provided by S&P Global.[3] With this information, we can reconstruct the volume invested in each contract and the total volume invested by CITs in the SP-GSCI. The total OI from the whole term structure is directly available from the CFTC report. We apply Masters and White (2008, p. 49-51) algorithm over the sample period (2000—2010).[4] The algorithm delivers the OI per contract attributable to CITs (VCIT). The share of total index investment (SCIT) is defined as VCIT divided by total OI; see the definition in the Appendix, Table A1.

We start the empirical analysis with the 27 SP-GSCI contracts. Following Bai et al. (1998), the dynamics of $\mathbf{SCIT_t}$ is a Vector Auto Regression with q lags, $q = 1, 2, \ldots, 10$, and

[1]See http://www.cftc.gov/MarketReports/CommitmentsofTraders/index.htm

[2]For the same reasons, swap dealers could claim position limits exemptions as if they were producers or processors in need of hedging.

[3]We thank S&P Global for providing us with the historical SP-GSCI weights.

[4]For 1999, we start with the January figures in Masters and White (2008) and the first figures available in 2000. Then, we make a linear interpolation and allocate the corresponding amounts to each month.

the number of lags is chosen based on the Bayesian Information Criterion (BIC), computed over the full sample with no breaking covariates. We test for a break on the intercept since we are primarily interested in a structural shift in the level (mean) of the index investment (and not in the trend). We estimate the following equation:

$$\mathbf{SCIT_t} = \left({}^{\mathbf{T}}\mathbf{G_t} \otimes \mathbf{G_t}\right)\theta + d_t\left(k\right)\left({}^{\mathbf{T}}\mathbf{G_t} \otimes \mathbf{I_n}\right){}^{\mathbf{T}}\mathbf{SS}\delta + \epsilon_{\mathbf{t}}, \tag{1}$$

where ${}^{\mathbf{T}}\mathbf{SCIT_t} = \left[SCIT_{c,t}\right], c = 1, 2, \ldots, 27$, ${}^{\mathbf{T}}\mathbf{G_t}$ is a row vector containing $\mathbf{SCIT_{t-1}}$, $\mathbf{SCIT_{t-2}}, \ldots, \mathbf{SCIT_{t-q}}$, n the number of equations, and $\mathbf{S}$ a selection matrix such that only the intercept is allowed to break with $\mathbf{S} = s \otimes \mathbf{I_n}$ and $s = [1, 0, \ldots, 0]$. Eq. 1 is estimated for every date k, such that $d_t\left(k\right) = 0$ if $t < k$ and 1 otherwise. The potential break date is the value of k that generates the maximum F-statistic, which is statistically significant as soon as this statistic is higher than the limiting χ^2 distribution. Finally, the confidence intervals are constructed for three levels of statistical significance, *i.e.* 90%, 95%, and 99%; see Bai et al. (1998, p. 401).

4. Empirical results

4.1. Break test

Table 1 reports the results concerning the existence of a common break affecting CITs' monthly market share of the SP-GSCI components. With the BIC computed over the full sample (and no break), we select a Vector Autoregression with five lags. The Bai et al. (1998) algorithm described in Section 3.1 identifies a break in December 2003.[5] The financialization materializes at a date close, or equal to that retained by Sanders and Irwin (2011), Buyuksahin et al. (2009), and Boons et al. (2014) among others. When we restrict the sample to the CFTC contracts, the break date does not change. For robustness purposes, we repeat the test with the share of "commercial" long positions (SCL). A break is detected in November 2003, which is close to the one previously documented. When we focus on six non-indexed CFTC (ALT) contracts, we observe a significant break in April 2008, long after the previous ones. Altogether, these results are in favor of a break that occurs at the end of 2003.

[Insert Table 1 here]

[5] At the 1% level, this translates into a six-day confidence interval around the break date. The critical values are available in Bekaert, Harvey, and Lumsdaine (2002, p. 244).

The introduction of electronically traded futures contracts took place from August 2006 to October 2008. We test the null hypothesis (Hypothesis 1) that the inception of electronic trading dates lies inside the confidence interval of the break date. The corresponding Bonferroni test (19 simultaneous hypotheses) rejects the null hypothesis at the 1% level. We conclude that the financialization does not overlap with the electronification of individual commodity contracts. We are unaware of another alternative hypothesis that could explain the break documented here. Altogether, these results make us confident that the date identified as the financialization is unrelated to any other innovation at the exchange level.

5. Conclusion

In this paper, we examine the consequences of the financialization of commodity futures markets. We identify a common structural break in the SP-GSCI components that occurred in December 2003.

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Table 1: **Break detection in CITs' market share**

This table reports the break dates in the monthly CITs' market share series (SCIT). The break is determined with the Bai et al. (1998) algorithm. The sample covers the 1999—2010 period. Row 1 presents the results obtained with the 27 SP-GSCI contracts. In row 2, we reiterate the procedure with 21 SP-GSCI contracts only. We exclude contracts listed on the LME (Metals) for three main reasons: a) the roll is not well-defined, b) there is an unusual number of maturities for individual contracts, and c) the open interest of the contracts is not reliable. In row 3, only the 19 contracts covered by the CFTC are considered. Row 3 presents the break date for the "commercials" long positions (SCL) of the legacy report as an alternative proxy for CITs' market share series. Row 4 reports the results for six non-SP GSCI/CFTC contracts. The estimation involves vector auto-regression with the number of lags determined with the Bayesian Information Criterion. We test for a break in the intercept. We report the mean breakpoints and the 90%, 95%, and 99% confidence intervals for the break. We report the intercept increase (mean change) after the w.r.t. before the breakpoint in % and the Sup-Wald statistics as well as its significance level based on the asymptotic critical values obtained by simulation in Bekaert et al. (2002). *** indicates a significance level of 1%.

Variables	1999–2010							
	# Contracts	BIC	Break date	CI (10%)	CI (5%)	CI (1%)	Intercept ($\times$ 100)	Sup-Wald statistics
SCIT/SP-GSCI	27	5	Dec-03	0.00	0.08	0.25	6.17	204.78
SCIT/SP-GSCI	21	5	Dec-03	0.07	0.10	0.20	6.53	225.60
SCIT/SP-GSCI/CFTC	19	5	Dec-03	0.08	0.11	0.21	3.81	196.88
CL/SP-GSCI/CFTC	19	4	Mar-03	0.53	0.76	1.07	3.40	55.92
CL/non SP-GSCI/CFTC	6	1	Oct-06	1.71	2.45	4.40	0.40	34.54

Appendix

Table A1: **Variable definition**

We define the variables, their units, frequency, period of availability, and additional descriptions if needed. The variables are computed over the 1999–2010 period.

Variable	Computation	Description	Source
Futures price	$F^m_{c,t}$	Price of a futures contract c, at time t, maturing at m.	Barchart
Futures price change	$r^m_{c,t} = \ln(F^m_{c,t}) - \ln(F^m_{c,t-1})$		
Cumulative abnormal price change	$CAPC^m_{c,w}$	CAPC of contract c, maturing at m, over the roll period r.	
Open interest per contract	$OI_{c,t}$	Open interest in USD of contract c at time t	CFTC Legacy report.
Total open interest	$TOI_t = \sum_c OI_{c,t}$		
Total SP-GSCI investment	See below		
Amount tracking SP-GSCI contracts	$VCIT_{c,t}$	See Masters and White (2008, p. 45-51)	
Market share of SP-GSCI contracts	$SCIT_{c,t} = {}^{VCIT_{c,t}}/_{OI_{c,t}}$	Market share of CITs on contract c, at time t.	
Market share of "commercials" long	$SCL_{c,t} = {}^{CL_{c,t}}/_{OI_{c,t}}$	Market share of "commercials" long on contract c, at time t.	
"Commercials" long	$CL_{c,t}$	"Commercials" long on contract c, at time t.	CFTC legacy report.
"Commercials" short	$CS_{c,t}$	"Commercials" short on contract c, at time t.	CFTC legacy report.
"Commercials" net long	$CNL_{c,t} = CL_{c,t} - CS_{c,t}$	"Commercials" net long on contract c, at time t.	
Hedging pressure	$HP_{c,t} = {}^{-CNL_{c,t}}/_{OI_{c,t}}$	Hedging pressure on contract c, at time t.	
Cross-hedging pressure	$HPG_{c,t} = -\frac{\sum_{g=\{G\}-c} CNL_{g,t}}{\sum_{g=\{G\}-c} OI_{g,t}}$	Hedging pressure on contract c, at time t, of group g.	
Short term change in hedging pressure	$Q_{c,t} = {}^{(CNL_{c,t}-CNL_{c,t-1})}/_{OI_{c,t-1}}$	Change in hedging pressure on contract c, from $t-1$ to t.	
Average hedging pressure	$AHP_{c,t} = \frac{1}{52}\sum_{\tau=t-51}^{t} HP_{c,\tau}$	52-week average hedging pressure.	
Cross short-term	$QG_{c,t} = \frac{\sum_{g=\{G\}-c}(CNL_{g,t}-CNL_{g,t-1})}{\sum_{g=\{G\}-c} OI_{g,t}}$		
Average cross-hedging pressure	$AHPG_{c,t} = \frac{1}{52}\sum_{\tau=t-51}^{t} HPG_{c,t}$	52-week average cross-hedging pressure.	

Table A2: **Contract characteristics**

The Table reports the specifications of 26 contracts covered by the CFTC; 19 contracts are included in the SP-GSCI, and 7 are not. The reported characteristics are the trading venues, tickers, underlying commodities, units, maturity months with the appropriate code letter, and the inception date of the corresponding electronically traded contract.

Commodity	Trading venue	Ticker	Unit	Maturity	Electronification
			Panel A: SP-GSCI contracts		
Corn	CBT	C	bu (5,000)	HKNUZ	01/08/2006
Cocoa	ICE-US	CC	MT (10)	HKNUZ	02/02/2007
WTI crude oil	NYMEX/ICE	CL	bbl (1,000)	FGHJKMNQUVXZ	05/09/2006
Cotton	ICE-US	CT	lbs (50,000)	HKNVZ	02/02/2007
Feeder cattle	CME	FC	lbs (50,000)	FHJKQUVX	24/11/2008
Gold	CMX	GC	ozt (100)	GJMQVZ	04/12/2006
Heating oil	NYMEX	HO	gal (42,000)	FGHJKMNQUVXZ	05/09/2006
Coffee	ICE-US	KC	lbs (37,500)	HKNUZ	02/02/2007
Kansas wheat	KBT	KW	bu (5,000)	HKNUZ	13/01/2008
Live cattle	CME	LC	lbs (40,000)	GJMQVZ	04/12/2006
Brent crude oil	ICE-UK	LCO	bbl (1,000)	FGHJKMNQUVXZ	12/06/2006
Gasoil	ICE-UK	LGO	MT (100)	FGHJKMNQUVXZ	12/06/2006
Lean hogs	CME	LH	lbs (40,000)	GJMNQVZ	04/12/2006
Natural gas	NYMEX/ICE	NG	MMBtu (10,000)	FGHJKMNQUVXZ	05/09/2006
Orange juice	ICE	OJ	lbs (15,000)	FHKNUX	02/02/2007
Platinum	NYMEX	PL	ozt (50)	FGHJKMNQUVXZ	04/12/2006
RBOB gasoline	NYMEX	RB	gal (42,000)	FGHJKMNQUVXZ	05/09/2006
Soybeans	CBT	S	bu (5,000)	FHKNQUX	01/08/2006
Raw sugar	ICE-US	SB	lbs (112,000)	HKNVZ	02/02/2007
Silver	CMX	SI	ozt (5,000)	FHKNUZ	04/12/2006
Wheat	CBT	W	bu (5,000)	HKNUZ	01/08/2006
			Panel B: Non-indexed contracts		
Minneapolis Wheat	CME	MWE	bu (50,000)	HKNUZ	15/12/2004
Lumber	CME	LB	m^3 (110,000)	FHKNUX	20/10/2008
Class III Milik	CME	DC	lbs (200,000)	FGHJKMNQUVXZ	17/09/2007
Oats	CBOT	O	bu (5,000)	HKNUZ	01/08/2006
Palladium	NYMEX	PA	ozt (100)	HMUZ	04/12/2006
Rough rice	CBOT	RR	CWT (2,000)	FHKNUX	01/08/2006

Maturity month code: F = January, G = February, H = Mars, J = April, K = May, M = June, N = July, Q = August, U = September, V = October, X = November, Z = December.