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Market efficiency and price discovery: a comment on futures rollover practices

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Abstract

Studies of market efficiency and price discovery use financial time series data, a common example being that of spot and futures prices over a given time period. The spot series is considered 'continuous' and is taken from one specific asset. The futures series is more complicated. This is due to the fact that the futures series represents multiple contracts which are often traded simultaneously.

Empirical research shows clear support for the use of prices on the nearby contract for constructing the futures price series. It is less clear which method for rolling over from one futures contract to the next is preferred. Using the FTSE/JSE Top40 Index and futures contracts, two common rollover approaches are implemented: a rollover one day prior to contract expiry, and a rollover at the end of the month immediately prior to the expiry month.

It is found that results are largely unaffected by the choice of rollover procedure, however, there is evidence that the rollover decision influences the results of the vector error correction model. As a result, caution in choosing a rollover strategy and consideration of the economic and statistical sense of the chosen strategy is recommended when constructing a futures price series.

Key phrases

error correction; FTSE/JSETop40; futures rollover; price discovery

1. INTRODUCTION

Market efficiency, commonly understood as the incorporation of market related news into asset prices, has been a key discussion point spanning decades of debate and research. Studies which examine market efficiency almost invariably deal with asset prices, and it is not uncommon for empirical work of this nature to delve into the pricing theories and related concepts of the assets being analysed. In recent times, with the inception of new markets and financial assets, there has been a marked increase in the complexity of pricing instruments which trade across markets and which involve multiple assets linked to a common underlying security.

As a result, empirical work has moved away from the analysis of a markets' efficiency, or lack thereof, to modelling how information moves through these increasingly complex markets. Price discovery, which examines these informational flows, has been investigated in a variety of markets and instruments[1]. An analysis of price discovery uses an econometric analysis of a particular market or group of assets to comment on the assimilation of market news into asset prices.

One common area of price discovery research examines the flow of information between spot and futures markets linked to the same underlying security. Results from empirical research of the spot-futures case has generally found that futures markets lead the price discovery process, such that market information is assimilated in futures prices first, after which that information filters into spot prices. Findings of spot-led markets and instances of bidirectional causality have also been observed.

In order to examine the price discovery process between two assets, the first step required is to obtain price series across time for both assets. The spot and futures price series need to be ordered in such a way as to make them comparable. With the use of daily data this is commonly done by taking the closing prices of the spot and futures instruments. For the spot series, this is a straightforward observation of daily closing prices; there is one asset with one ticker (trade) code to follow.

For the futures series, however, there are multiple contracts traded at a time, and so there are multiple active (trading) ticker codes which can be observed at any given time. The challenge is to create a continuous price series from these multiple, and at times simultaneously occurring, price observations on these multiple futures contracts. Consequently, some guidelines need to be set in order to create a single futures time series which is comparable to the spot series.

2. CONSTRUCTION OF THE FUTURES SERIES

There are two matters which require consideration when formulating the futures series. The first question asks which contract should be used for the required price observations. This is a concern as there are usually three 'types' of futures contract trading at any given time: the

[1] As price discovery itself is not the focus of this particular paper, please consider reading Bose (2007) and Kumar and Chaturvedula (2013) for a detailed discussion on the literature and expanded methods of this topic.

'nearby contract' which is the most current contract with the closest expiry date; the 'next contract' which is the one with the next closest maturity date; and the 'far contract', which refers to the one(s) maturing after the next contract (Karmakar 2009:46). That is, the question of "which" refers to contract selection.

The second question asks when the researcher should move from using the prices of one contract to using the prices on another, subsequent, contract. The question of 'when' is the issue of rollover, and is the primary concern of this paper. It is impossible to construct a single futures price series without engaging with these issues, due to the fact that futures trade does not represent a single traded asset with a single price series. Rather, futures trade refers to a series of futures contracts all related to a common underlying asset, which trade at different, although sometimes overlapping, times of year.

In investigating the question of 'when', it became apparent that this was the murkier issue. To demonstrate: Chen and Zheng (2008); Karmakar (2009); and Zhong, Darrat and Otero (2004) all implemented a one-month-before rollover procedure. The reason given by Zhong *et al*. (2004:3039) for this was to avoid, "abnormal price variability that may occur during the delivery month". In contrast, Chu and Hsieh (2002); Kumar and Chaturvedula (2013); So and Tse (2004); and Srinivasan and Bhat (2009) all implemented a rollover the day before or on the maturity date of the futures contract. There are still others who suggested a rollover date between a 7 to 10 day period before the maturity of the nearby contract, for example Brooks, Rew and Ritson (2001) and Leng (2002). That is, empirical research on price discovery shows that studies are split between those who suggest an immediate or one day prior to expiry rollover, while others advocate a later rollover at 7-days, 10-days, or 1-month before expiry.

The 7-day, 10-day, 1-month suggestions are not as divergent as they appear to be, as they usually refer to number of trading days. Futures contracts on the FTSE/JSE Top40 expire on the third Thursday of the maturity month. Using September 2013 as an example, if the day of contract expiry (19th Sept) is included, this represents a rollover on the 11th Sept (7-day rollover), 6th Sept (10-day rollover) or 30th August (1-Month[2] rollover). The 'how-to' of rolling over is straightforward; however, it is not clear which rollover strategy is the best to use.

[2] While the notation "1-Month" is used, it should be noted that this refers to the rollover occurring at the end of the month immediately preceding the expiry of the nearby contract. It does not represent one whole month of trading days.

This paper aims to examine this problem by using the South African Top40 Index (FTSE/JSE TOP40) and associated futures contracts. A basic study of the price discovery relationship between these variables will be modelled using two different rollover approaches commonly observed in market efficiency and price discovery research. The results will then be used to comment on the sensitivity or lack thereof of the rollover process chosen.

3. LITERATURE REVIEW

This literature review is structured so as to examine the question of 'which' contract first. Following this, the question of 'when' contracts should be rolled over is addressed.

The first question can be answered unambiguously. The literature shows that the nearby contract is the most appropriate to use (see for example Chen and Zheng 2008:5; So and Tse 2004:895). Every paper examined by the author noted the use of the nearby futures contract. The reasons for using the nearby contract were that it was more active (So & Tse 2004:895) and because it was seen to be more heavily traded (more liquid) than the next and far month contracts (Srinivasan & Bhat 2009:32). It was noted by Karamaker (2009:46) that the nearby contract "always exhibits more trading volume" and further that "the more actively traded an instrument is, more is the information contained in its price." Given this evidence, this paper will use the nearby contract for its price observations.

In examining the literature for the answer to 'when' to rollover, it is evident that empirical work, especially recent research, which specifically focusses on rollover practices, is limited. A number of studies examine problems related to the rollover question, such as Frino and McKenzie (2002) who examined calendar spreads when investors rollover their exposure to the futures market, and Mouakhar and Roberge (2010) who examined optimal rollover strategies for portfolios. These are, however, not specifically aimed at futures price series construction practices – i.e. the 'when' of rollover.

Ma, Mercer and Walker (1992:205-206) state that a number of rollover practices are employed in empirical studies and that rollover practices need to be examined in order to determine the "economic and statistical differences associated with commonly used rollover methods." Ma *et al.* (1992:206) estimated three common types of empirical studies which used futures prices: risk-return combinations related to buy-and-hold trading strategies; the relationship or serial dependence between price changes/returns – a common methodology with which market efficiency is examined (1992:207); and the influence on payoff distributions. These three tests were rerun a number of times, each with the futures price series constructed under a different rollover procedure.

Ma *et al.* (1992:211) notes that the choice of rollover method resulted in an observed bias in the estimated results. Ma *et al.* (1992:216) further note that their results did not allow for a 'best' method to be recommended as this decision may relate directly to the contract itself. That is, each futures series would need to be examined independently as the contract itself may be impacting on the characteristics of the constructed futures price series. In addition, Ma *et al.* (1992:216) suggest that rollover on the delivery date be avoided due to the increased volatility introduced into futures prices on that date.

More recent commentary on this matter is found in Carchano and Pardo (2009). Given Ma *et al.*'s (1992) finding that results may be contract-specific, Carchano and Pardo (2009:686) focused on one type of contract: equity index futures. Equity index futures were chosen as they were viewed as being more 'standard' than futures contracts on commodities such as energy and agriculture.

Carchano and Pardo (2009:686-687) used four criteria related to market liquidity with which to select rollover dates: volume; open-interest; the liquidity ratio method of Lucia and Pardo (2008); and lastly, the mathematical characteristics of the series, as per Geiss's (1995) method. Using the DAX, NIKKEI and S&P500 futures, Carchano and Pardo's (2009:691) methodology involved comparing the equality of the series characteristics in terms of mean (tested with the parametric F test), median (tested with the non-parametric Kruskal-Wallis test) and standard deviation (tested with the Brown-Forsythes's statistic). These results, regardless of rollover practice, indicated equality of mean, median and standard deviation concluding that the series where the same in terms of these characteristics despite the different rollover practices applied (Carchano & Pardo 2009:691).

Carchano and Pardo (2009:691-692) then noted that series with the same mean and median (the 'parameters of position'), and the same standard deviation (parameter of dispersion) may still have different distributions. As a result, they also tested the series for the respective distributions of the series with the Wilcoxon/Mann-Whitney test and again concluded that the results were similar, regardless of rollover practice. Carchano and Pardo (2009:693) suggest that this may be supportive of the findings they cited of Daal, Farhat and Wei (2006) and Duong and Kalev (2008) who found evidence that many futures contracts did not display a maturity effect. Carchano and Pardo (2009:693) conclude that rollover practice did not induce bias (as was indicated by Ma *et al.* (1992)) and so they recommend that rollover be made the day prior to expiry, this being the simplest measure to use.

It should be noted that Carchano and Pardo (2009) examined the constructed futures series in terms of its characteristics under various measures; they did not use those series in an empirical research framework as was done by Ma *et al.* (1992). Given that Ma *et al.* (1992) indicate that empirical work may be biased by rollover practice, the approach of their work is used here, in addition to the examination of the constructed series characteristics, as per Carchano and Pardo (2009).

4. DATA

The data for this study consists of daily closing prices on the FTSE/JSE Top40 Index and the Futures contracts on the FTSE/JSE Top40 Index. Observations for each series were taken from the start of January 2003 until the end of August 2013. Index and Index Futures data was obtained from Bloomberg's Professional.

The nearby futures contract was used in order to ensure liquidity and informational content of the prices used. Futures contracts on the FTSE/JSE Top40 expire in March, June, September and December of each year on the 3rd Thursday of those months. It is noted that these exchanges have different final trade times. The *index* final trade occurs at 17:00, while the *futures* final trade occurs at 17:30. As this paper does not seek to comment on market efficiency or price discovery itself, the time differential is ignored.

The futures price series was constructed in two ways, a visual description of which is shown in Table 1. The first method involved rolling over from the nearby contract to the next contract 1-day prior to the nearby contracts expiry date. To demonstrate: the September 2013 contract expired on 18th September and so the last price taken from the September 2013 contract was on 17th September 2013. The observation on the 18th September 2013 was the price for the December 2013 contract on 18th September 2013.

TABLE 1: **Futures rollover procedures**

Calendar date	Future price series	
	Rollover 1 day	Rollover 1 month
29 August 2013	29 Aug price on the SEPT 2013 contract	29 Aug price on the SEPT 2013 contract
30 August 2013	30 Aug price on SEPT 2013 contract	30 Aug price on SEPT 2013 contract
2 September 2013	2 Sept price on SEPT 2013 contract	2 Sept price on DEC 2013 contract
3-16 September 2013	3-16 Sept prices on SEPT 2013 contract	3-16 Sept prices on DEC 2013 contract
17 September 2013	17 Sept price on SEPT 2013 contract	17 Sept price on DEC 2013 contract

Calendar date	Future price series	
	Rollover 1 day	Rollover 1 month
18 September 2013	18 Sept price on DEC 2013 contract	18 Sept price on DEC 2013 contract
19 September 2013	19 Sept price on DEC 2013 contract	19 Sept price on DEC 2013 contract

Source: Generated by author from Bloomberg's data on the FTSE/JSETop40 contract

The second futures series was created by rolling over at the end of the month immediately prior to the nearby futures contracts expiry (the '1-month' rollover). To demonstrate: using the same September 2013 contract, prices were taken for the September 2013 contract until the end of August 2013. From 2 September 2013, the prices are those of the December 2013 contract. This procedure was completed manually off the daily individual contracts prices, resulting in a sample of 2668 observations on each series.

There were two instances in the 1-month rollover series where one price was missing: the 4 September 2003 price for the September 2003 contract, and the 6 December 2005 price for the March 2006 contract. In both instances an index price was present for that day indicating that the market as a whole was actively trading.

Given that the missing observations are from 2003 and 2005, there was difficultly in establishing the reason for this. The decision was made that the last price be carried forward (rather than using interpolation or some other midpoint). The reason for this was that market participants would presumably have had the previous day's closing price and so that price best represents the information available (compared with some manufactured price). This represents 2 of a total of 2668 observations, and so it is anticipated that the effects would be negligible.

5. METHODOLOGY

These price series were converted into log form in order to proceed with the price discovery analysis. Each series is then tested for the presence of a unit root using the Augmented Dicky-Fuller (ADF) Test. This is done because time series data is frequently non-stationary, which has implications for the type of analysis used. The ADF test is run on each series (the index spot and both futures series) in order to ascertain that each series is correctly identified as stationary or non-stationary. The unit root hypothesis is that the coefficient tied to the lagged term will be zero, which is indicative that the given time series is non-stationary (Gujarati 2006:497). The ADF test was repeated on each series in first difference form (FDF) in order to establish the order of integration.

Descriptive Statistics are then generated on the two futures series in FDF in order to observe whether any significant difference can be noted. Stationary data is preferred for the formulation of descriptive statistics, and so these are run after the testing for unit roots - the purpose being to comment on differences in the two futures series and to test for equality between the two; that is, whether or not the choice of rollover procedure affected the characteristics of the resultant futures series is examined in line with Carchano and Pardo (2009).

The next stage involves establishing whether the spot and futures series have a long-run cointegrating relationship. This is determined through the use of the Trace and Maximum Eigenvalue (ME) Tests associated with Johansen's Cointegration methods. These tests are run twice: once with the index against the 1-day rollover[3], and again with the index against the 1-month rollover[4].

The Trace test examines the joint hypothesis that the number of cointegrating vectors is less than or equal to r against the alternative that there will be more cointegrating vectors than r (Brooks 2008:351). The null hypothesis of this approach states that variables are not cointegrated and have a rank of zero. The alternative hypothesis states that at least one or more of the cointegrating vectors will have a rank greater than zero (Enders 2004:364). The ME test examines each eigenvalue individually and tests the null hypothesis that the number of cointegrating vectors is r compared with the alternative hypothesis that there exists $r + 1$ cointegrating vectors (Brooks 2008:351). Enders (2004:323) states that, if an equation contains two non-stationary variables then, at most, one cointegrating relationship can exist and the rank of the matrix will be, at most, 1.

Following the results of the Trace and ME tests, a lag length criteria test is run in order to determine optimal lag length. This is a necessary precursor to the final stage, which can be sensitive to lag length decisions. Using the optimal lag length determined above, the Index/1-day and Index/1-month series are then examined within a Vector Error Correction Model (VECM). Being able to determine in which market the point of price discovery lies may be considered the pivotal finding in this model (Mahalik, Acharya & Babu 2009:4). The VECM is estimated as follows, adapted from Karmakar (2009:45):

[3] Hereafter Index/1-day

[4] Hereafter Index/1-month

$$\Delta S_t = \alpha_1 + \alpha_S \hat{\varepsilon}_{t-1} + \sum_{i=1} \alpha_{11}(i)\Delta S_{t-1} + \sum_{i=1} \alpha_{12}(i)\Delta F_{t-1} + \varepsilon_{St}$$

$$\Delta F_t = \alpha_2 + \alpha_F \hat{\varepsilon}_{t-1} + \sum_{i=1} \alpha_{21}(i)\Delta S_{t-1} + \sum_{i=1} \alpha_{22}(i)\Delta F_{t-1} + \varepsilon_{Ft}$$

Two aspects of a VECM model are used in interpreting the price discovery relationship. The first is the error correction terms (ECT) α_S and α_F, where at least one of the two needs to be statistically significant, as this indicates a cointegrating relationship and the correction of short run deviations to the long-run equilibrium (Enders 2004:338).

Mahalik *et al.* (2009:11) state that, if the ECT on the Spot (Futures) series is found to be statistically insignificant, a change in the current period's Spot (Futures) price does not respond to deviations from the equilibrium that occurred in the previous period. That is, when the futures price ECT is statistically significant, this is an indication that the futures prices are responding to movements away from the long-run equilibrium, and that it is the futures prices which are responding first in order to maintain the equilibrium price. Thus, the futures market leads the spot market. The absolute values of the ECT's should not be overly large as they estimate the rate of convergence to the long-run equilibrium (Enders 2004:338).

The second component examined in the VECM is that of the lagged coefficients to the spot and futures prices. Karmakar (2009:45) provides an explanation for the interpretation of the lagged values and the role of price discovery in this model: If the coefficient on the lagged futures price in the spot price dependent equation is statistically significant, then turning points in the futures market lead turning points in the spot market; so futures changes cause spot changes.

A reminder that the purpose of following the methodology of price discovery is simply to allow for the effect of rollover practices in studies of this nature to be commented on - it is not for a full analysis of the price discovery processes of this particular market. As such, the price discovery analysis may appear 'weak' in comparison to a paper focused on price discovery, however, the analysis here is aimed at rollover practice effects. The results are discussed in the next section; and as noted above, the focus is in the interpretation of these results in terms of noting any differences/similarities that may be occurring as a result of the rollover method used, rather than on an analysis of price discovery in this market.

6. RESULTS

6.1 Organisational culture as a concept

Results for the ADF tests, run with trend and intercept applied, are displayed in Table 2, with statistical significance indicated with *. The Top40 Index, the Futures 1-Day and Futures 1-Month Series showed the presence of a unit root in level (log) form. In all cases the series became stationary in FDF, indicating series are integrated of order I(1). Conclusions were unaffected by the type of ADF test run (with or without intercept and/or trend), or by the number of lags included.

TABLE 2: ADF test for stationarity and data order

	Spot index series		Future price series			
			Rollover 1 day		Rollover 1 month	
	t-statistic	Prob.	t-statistic	Prob.	t-statistic	Prob.
ADF in Levels	-1.640463	0.7768	-1.651844	0.7721	-1.896653	0.6559
ADF in FDF	-25.69923	0.0000*	-23.57002	0.0000*	-51.37131	0.0000*

Source: Generated using EViews Statistical Software Package

6.2 Descriptive Statistics and Tests of Equality

The Futures 1-Day and Futures 1-Month Series were then examined in FDF in order to comment on the descriptive statistics for these two series constructed with different rollover procedures. Results are shown in Table 3.

TABLE 3: 1-day and 1-month descriptive statistics on FDF futures series

	Future price series	
	Rollover 1 day	Rollover 1 month
Mean	0.000546	0.000546
Median	0.000823	0.000795
Std. Dev.	0.014322	0.014269
Skewness	-0.031375	-0.059532
Kurtosis	5.634669	5.484914
Jarque-Bera	771.8097	687.7498
Probability	0.000000	0.000000

Source: Generated using EViews Statistical Software Package

Differences in the table are highlighted; however, these differences appear small. This is in line with the findings of Carchano and Pardo (2009) who noted no real difference in the parameters of position or dispersion. Again, in line with Carchano and Pardo (2009) equality tests, displayed in Table 4, were run.

TABLE 4: 1-day and 1-month tests of equality

Test for equality of means between series			
Method	df	Value	Probability
t-test	5332	-8.76E-16	1.0000
Anova F-test	(1, 5332)	7.67E-31	1.0000
Welch F-test*	(1, 5331.93)	7.65E-31	1.0000
*Test allows for unequal cell variances			

Test for equality of medians between series			
Method	df	Value	Probability
Wilcoxon/Mann-Whitney		0.026514	0.9788
Med. Chi-square	1	0.000750	0.9782
Kruskal-Wallis	1	0.000703	0.9788

Test for equality of variances between series			
Method	df	Value	Probability
F-test	(2666, 2666)	1.007393	0.8492
Siegel-Tukey		0.099299	0.9209
Bartlett	1	0.036158	0.8492

Source: Generated using EViews Statistical Software Package

Equality tests have a null hypothesis that the series are equal in terms of a stated characteristic (mean, median, then variance); these results indicate that the futures series are equal. Skewness and Kurtosis are both slightly different under the two rollover procedures. The null hypothesis of the Jarque-Bera (JB) test is that the residuals are normally distributed. The JB statistics of 771.8097 and 687.7498 are both statistically significant, indicating a rejection of the null hypothesis; so neither series is normally distributed.

6.3 Tests for Cointegration and Lag Length

Having established that the individual series are all non-stationary in their log forms, the next step was to examine the index and futures series for the presence of a long-run cointegrating relationship using the Johansen's Trace and ME Tests, the results of which are shown in Table 5.

These results are a summation of the Trace and ME tests run under a set of different assumptions. Financial time series data would commonly use the 'linear data trend, intercept and no trend' (highlighted) assumption, however, all assumptions were examined for full comparison. The presence of one cointegrating relationship, in line with our *a priori* expectation, is observed in both series.

TABLE 5: Trace and maximum eigenvalue tests of cointegration

Assumptions	INDEX _ rollover 1 day		INDEX _ rollover 1 month	
	TRACE	ME	TRACE	ME
	Number of cointegrating relationships (5% stat. sig.)			
No data trend, no intercept, no trend	2	2	2	2
No data trend, intercept, no trend	1	1	1	1
Linear data trend, intercept, no trend	1	1	1	1
Linear data trend, intercept, trend	1	1	1	1
Quadratic data trend, intercept, trend	1	1	1	1

Source: Generated using EViews Statistical Software Package

Before moving into an examination of the price discovery process and VECM analysis, it is necessary to examine the most appropriate lag structure to use in the VECM. This was done by using a lag length criterion test where multiple criteria are applied. Results are taken from the test run with 10 lags, however, results were tested at various imposed lag structures and remained consistent.

The results in Table 6.1 for the Index/1-day relationship show that the use of a 4-lag structure is appropriate. The results in Table 6.2, examining the Index/1-month combination, are more mixed, with two measures indicating 4-lags, two indicating 5-lags, and one suggesting a 2-lag structure.

The results in Table 6.2, examining the Index/1-month combination, are more mixed, with two measures indicating 4-lags, two indicating 5-lags, and one suggesting a 2-lag structure.

TABLE 6.1: Lag length criteria test index/1-day

Lag	LogL	LR	FPE	AIC	SC	HQ
0	8336.671	NA	6.48e-06	-6.271385	-6.266957	-6.269782
1	19389.90	22081.51	1.59e-09	-14.58533	-14.57204	-14.58052
2	19548.96	317.5224	1.41e-09	-14.70200	-14.67986*	-14.69399
3	19561.91	25.82095	1.40e-09	-14.70873	-14.67773	-14.69751
4	19574.20	24.49735*	1.39e-09*	-14.71497*	-14.67511	-14.70055*
5	19577.41	6.406932	1.40e-09	-14.71438	-14.66567	-14.69675
6	19580.96	7.054886	1.40e-09	-14.71404	-14.65647	-14.69320
7	19583.84	5.736490	1.40e-09	-14.71320	-14.64677	-14.68916
8	19585.18	2.649728	1.40e-09	-14.71119	-14.63591	-14.68395
9	19586.09	1.812133	1.40e-09	-14.70887	-14.62473	-14.67842
10	19587.89	3.575598	1.41e-09	-14.70722	-14.61422	-14.67356
* indicates lag order selected by the criterion (each test at 5% level)						
LR: sequential modified LR test statistic AIC: Akaike information criterion FPE: Final prediction error SC: Schwarz information criterion HQ: Hannan-Quinn information criterion						

Source: Generated using EViews Statistical Software Package

TABLE 6.2: Lag length criteria test index/1-month

Lag	LogL	LR	FPE	AIC	SC	HQ
0	8076.520	NA	7.88e-06	-6.075636	-6.071207	-6.074033
1	19377.68	22576.81	1.60e-09	-14.57613	-14.56285	-14.57132
2	19545.85	335.7113	1.42e-09	-14.69966	-14.67752*	-14.69165
3	19558.25	24.72713	1.41e-09	-14.70598	-14.67498	-14.69476
4	19572.70	28.80704*	1.40e-09	-14.71385	-14.67399	-14.69942*
5	19577.11	8.773190	1.40e-09*	-14.71415*	-14.66544	-14.69652
6	19580.50	6.762453	1.40e-09	-14.71370	-14.65613	-14.69286
7	19581.72	2.414993	1.40e-09	-14.71160	-14.64518	-14.68756
8	19583.72	3.980026	1.40e-09	-14.71010	-14.63482	-14.68285
9	19584.69	1.932885	1.40e-09	-14.70782	-14.62368	-14.67737
10	19586.44	3.468059	1.41e-09	-14.70613	-14.61313	-14.67247
* indicates lag order selected by the criterion (each test at 5% level)						
LR: sequential modified LR test statistic AIC: Akaike information criterion FPE: Final prediction error SC: Schwarz information criterion HQ: Hannan-Quinn information criterion						

Source: Generated using EViews Statistical Software Package

As the lag results were more varied with the 1-Month Future series, it was concluded that the VECM be estimated with a 4-lag structure on both series combinations, but to also check that the 1-Month series VECM results were unaffected by a change to 2 or 5 lags. Doing so indicated that results were not sensitive to lag changes, therefore the VECM estimations displayed relate to a 4-lag structure. Table 7 contains the VECM output, with standard errors in ( ) & t-statistics in [ ].

TABLE 7: VECM index/1-day and index/1-month

INDEX/1-DAY VECM			**INDEX/1-MONTH VECM**		
Cointegrating Eq	CointEq1		**Cointegrating Eq**	CointEq1	
LOG_TOP40(-1)	1.000000		LOG_TOP40(-1)	1.000000	
LOG_F1DAY(-1)	-1.001805		LOG_F1MON(-1)	-1.002251	
	(0.00142)			(0.00178)	
	[-703.849]			[-564.550]	
C	0.022685		C	0.029001	
Error Correction	D(LOG_TOP40)	D(LOG_F1DAY)	**Error Correction**	D(LOG_TOP40)	D(LOG_F1MONTH)
CointEq1	0.077951	0.156385	CointEq1	0.066444	0.128788
	(0.05232)	(0.05342)		(0.04685)	(0.04759)
	[1.49004]	[2.92729]		[1.41831]	[2.70645]
D(L_TOP40(-1))	-0.271701	0.112584	D(L_TOP40(-1))	-0.121495	0.275195
	(0.10946)	(0.11178)		(0.10815)	(0.10986)
	[-2.48223]	[1.00722]		[-1.12334]	[2.50498]
D(L_TOP40(-2))	-0.174854	-0.055790	D(L_TOP40(-2))	0.004904	0.130880
	(0.11552)	(0.11796)		(0.11467)	(0.11648)
	[-1.51365]	[-0.47294]		[0.04276]	[1.12364]
D(L_TOP40(-3))	-0.043613	0.014077	D(L_TOP40(-3))	-0.000948	0.066375
	(0.11431)	(0.11673)		(0.11376)	(0.11555)
	[-0.38152]	[0.12059]		[-0.00833]	[0.57442]
D(L_TOP40(-4))	-0.189684	-0.192801	D(L_TOP40(-4))	-0.125055	-0.144614

INDEX/1-DAY VECM			INDEX/1-MONTH VECM		
	(0.10389)	(0.10609)		(0.10379)	(0.10542)
	[-1.82581]	[-1.81732]		[-1.20493]	[-1.37177]
D(L_F1DAY(-1))	0.282876	-0.099521	D(L_F1MON(-1))	0.133172	-0.261057
	(0.10725)	(0.10952)		(0.10643)	(0.10811)
	[2.63751]	[-0.90868]		[1.25123]	[-2.41472]
D(L_F1DAY(-2))	0.156710	0.038131	D(L_F1MON(-2))	-0.022951	-0.147313
	(0.11334)	(0.11574)		(0.11297)	(0.11475)
	[1.38272]	[0.32946]		[-0.20317]	[-1.28382]
D(L_F1DAY(-3))	-0.023293	-0.084867	D(L_F1MON(-3))	-0.065605	-0.130314
	(0.11221)	(0.11458)		(0.11202)	(0.11379)
	[-0.20759]	[-0.74065]		[-0.58564]	[-1.14523]
D(L_F1DAY(-4))	0.164600	0.172828	D(L_F1MON(-4))	0.099398	0.126538
	(0.10200)	(0.10416)		(0.10206)	(0.10367)
	[1.61369]	[1.65922]		[0.97393]	[1.22062]
C	0.000608	0.000595	C	0.000605	0.000586
	(0.00027)	(0.00028)		(0.00027)	(0.00028)
	[2.23685]	[2.14499]		[2.22362]	[2.12181]

Source: Generated using EViews Statistical Software Package

Given the size of the sample used here, the degrees of freedom on the t-statistics are taken at the ∞ level, which represents a critical value of 2.3263 at the 1% level. This is a result of using as large a sample as this, corresponding to decreasing standard errors and increasing t-statistics which potentially inflate the acceptance region (Brooks 2008:59). As result, the 10% level of significance is ignored and precedence is given to the more stringent 1% level.

6.4 Price Discovery within the VECM

Table 7 shows that, in both cases, the VECM indicates one statistically significant ECT, both associated with the futures dependent equation, both indicating the same positive direction of change and a similar size (15% correction on the 1-Day series and a 13% correction on the 1-Month series). The spot ECTs in both are statistically insignificant, indicating that the spot market is unresponsive to error in the previous period (Leng 2002:11).

Some differences are noted when examining the significance of the lagged terms (which indicate how past values affect current values). In the 1-Day series, there is evidence to suggest the Top40 index is affected by its own past prices at lags 1 and, to a lesser extent, lag 4, as well as by past futures prices at lag 1. This is evidence of bi-directional causality as the spot dependent results can be read that spot causes spot (at lags 1 and 4) (at lag 1). In the futures-dependent results it can be read that futures causes futures (lag 4) and spot causes futures (lag 4).

These 4th lag results, however, are not apparent on the 1-Month VECM, where it is seen that the futures series is affected by past prices on the index and on itself (both at the first lag); neither past spot nor futures prices influence the spot series-dependent equation. Again, this is evidence of bi-directional causality, although the fact that the ECTs on the futures-dependent equations are the ones that are significant indicates that the futures market is responsible for the long-run equilibrium.

That is, the use of the ‘smoother’ 1-Month series shows fewer statistically significant price movements than the 1-Day VECM. While the overall findings are the same in both, the specific details differ, despite equality in mean, median and variance. This may be attributed to the fact that equality tests examine a single variable at a time. That is, this ‘equality’ does not take into account the correlation and covariance structure of the relationship between variables. As the VECM specifically examines the relationship, it is not unsurprising that different results are obtained.

7. CONCLUSION

The answer to ‘which’ contract to use when constructing the futures price series was clearly indicated as that of the nearby contract. In this manner the first question asked was clearly answered: the prices observed on the nearby contract should be used in the construction of the futures price series. Even if prices for multiple contracts are available on a given date, the price of the nearby contract is given preference in the process of constructing a single futures price series for a particular asset.

The question of ‘when’, however, was a more challenging question to address. Initial findings indicated that the two futures series were equal in terms of their mean, median and variance characteristics. Applying these series to the empirical methodology of a price discovery paper resulted in the same ADF and Johansen co-integration results.

Importantly, however, these two futures series displayed *different* results under the VECMs. This is an important note in the context of price discovery as this is the model used to comment on the lead-lag relationship. The ECTs of the VECM drew the same conclusion, namely: that the futures market was responsible for maintaining equilibrium. The lagged coefficient values were different under the two rollover procedures, although it was concluded that there was evidence of bi-directional feedback in both. That is, the question of 'when' is not trivial – rollover is evidenced here to affect the inferences that one draws with regard to the price discovery process of a given market. This is due to the VECM's examination of the causality and correlation between the variables, rather than the variables individual stand-alone characteristics.

In the analysis of price discovery, it is suggested that greater informational detail is required. As such, these results arguably indicate that the 1-Day rollover procedure provides greater detail and a more accurate indication of market informational effects, compared with the 'smoothed' 1-month series. As a result, this seems to indicate that the 1-Day rollover would be the preferred construction technique to use.

Possibilities for future research include trying to identify the 'best' method of rollover; however, in the meantime it is suggested that researchers using constructed future series pay special attention to their rollover selection, making sure to check its effects and justify their final decision in terms of the research question at hand.

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