Price Interaction between UK Covered Warrants and their Underlying Shares: A Panel Cointegration Approach

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Abstract

This paper contributes to the literature by marking the first attempt to investigate the UK covered warrants market, which first emerged in October, 2002. The paper delineates the theme of a new nonlinear panel unit root test, which mitigates the cross sectional dependences between the series. The empirical results demonstrate that the synchronous trading in UK leads to a long-run price equilibrium, with no lead and lag relation between covered warrants and their underlying shares. Thus, covered warrants permit approximations of the underlying share prices, based on the results of an estimation of implied share prices.

EFM Classification Codes: 410 - Options

JEL *classification*: G15, G19

Keywords: Covered warrants, Panel unit root, Panel cointegration, Price discovery.

1. Introduction

This study contributes to the literature on derivatives through its investigation of the UK covered warrants market, which first emerged in October, 2002; furthermore, we conduct an empirical analysis to provide a substantial explanation for the cointegration relation between covered warrants and their underlying shares, due to contemporaneous information transmission. This paper also contributes to delineating the theme of panel unit root tests performed by Pesaran (2007) and Cerrato *et al.* (2008), which account for the cross sectional dependences between the pairwise series and nonlinearity. Finally, using Pedroni (1995, 2004) and Kao's (1999) panel cointegration model, we take a novel approach to capture the dynamic of the two markets within daily trading.

The introduction of options in the 1970's stemmed from the need for a hedging and speculative tool. Following this introduction, scholars such as Black (1975) and Roll (1977) proposed that financial derivatives serve the purpose of improving information efficiency. Further, Biais and Hillion (1994) examined the changes in insider and liquidity trading following the introduction of the options market, and found that the options market conveyed more information, leading them to surmise that the options market completes the share market. Still, one part of the debate in the financial literature in support of the efficient market hypothesis concerns the question of whether two financial instruments with the same underlying assets have an impact on each other. In a perfect market, price discrepancies should be arbitraged away instantly, and therefore derivatives should neither lead nor lag their underlying stocks. In contrast, Stein (1987) suggested that the trading of options brings in more noise traders and makes the market less efficient. This opinion was earlier emphasized by Figlewski (1981) and Cox (1976), who both claimed that traders with low quality information destabilize the cash market. It seems conspicuous that, with the same underlying assets, the trading of financial derivatives such as options and their underlying shares is prone to an information transmission relation. In other words, there exists a possible reciprocal relation between the underlying share and the derivative.

Covered warrants were first introduced in late 1980's[1]; like options, they give the warrant holder the right to purchase or sell the underlying assets at a strike price during a certain period. Two distinct differences between covered warrants and options concern synchronous trading and the market segmentation for legislative reasons. The covered warrants market alleviated both of these concerns. If the market is efficient, new information pertaining to either the underlying shares or the covered warrant is immediately transmitted to other related

[1] The Frankfurt and Honk Kong markets both claim to have issued the first covered (derivatives) warrants in 1989.

assets. As a consequence, the existence of information transmission and a cointegrated relation between covered warrants and their underlying shares is plausible. Therefore, in this paper we propose the "synchronous trading hypothesis", claiming that since the two financial instruments are traded synchronically on the same platform, there should not be a significant lead and lag relationship if we apply a daily data series.

The remainder of this paper is organized as follows: the second section introduces the trading of covered warrants in UK; section three reviews previous literature on the price discovery function and our hypotheses; section four is concerned with data and methodology; and section five presents an analysis of the results together with some general conclusions.

2. The UK covered warrants market

Covered warrants were first introduced in Germany, and Hong Kong. Unlike traditional equity warrants, covered warrants issuers consist of third parties, namely investment banks and securities houses. In addition, most covered warrants today trade on the same platform as their underlying shares in many countries such as Italy, the UK, Taiwan, Australia and Hong Kong. Since the year 2000, covered warrants markets worldwide have experienced a boost, and the tendency to launch this type of instrument grown.

Table 1 presents the development of covered warrants around the world after 2002, which has proven to be a stage of rapid growth as covered warrants have risen in popularity. Panels A and B illustrate trading in covered warrants market around the world. Further, most covered warrants in Italy, Taiwan and the UK are associated with underlying assets in their local markets, which equate with a lesser chance of experiencing either foreign exchange rate risk or un-synchronic trading problems when examining the cointegration relation between the warrants and their underlying assets.

While the UK covered warrants market only attained a trading value of US$419.7 million in its first year of trading, since that time they have generated a high growth rate in terms of trading value every subsequent year. In 2006, the total trading value reached a high of US$1,346 million. In fact, both the trading value and the number of listed covered warrants have shown a rising tendency. In terms of specifics, most of the underlying assets are based on shares listed on the London Stock Exchange, although covered warrants with underlying assets based on an index, a currency, metals, or crude oil appear occasionally. Some covered warrants have proven quite innovative: in 2003, SG issued a basket of covered warrants consisting of "underlying shares associated with the Football World Cup", including shares pertaining to the soft drink, transportation, and alcohol sectors, among others. The issuance of covered warrants in the UK is authorized by the London Stock Exchange, while the Financial Services Authority (FSA) retains a supervisory role pertaining to the establishment of warrant trading regulations. Covered warrants are traded via the same individual's share trading account. Individual market participants do not have to submit further documentation to obtain a qualification to trade in covered warrants. This great convenience is seen as one of the major benefits related to trading in covered warrants in the UK, and has led to lower transaction costs.[2] In addition, the synchronous trading of covered warrants and their underlying assets has resulted in a tendency for strong information linkage between the two assets.

Motivated by the facts that the covered warrants market is now thriving and that UK covered warrants have not received sufficient attention thus far, this paper aims to examine these relatively new financial derivatives within this developed capital market. Requiring only one trading account, covered warrants allow traders to better perform hedging and speculation functions, while synchronous trading improves information transparency, which in turn reduces transaction costs and increases market efficiency.

[2] When trading other products with a similar origin, investors might have to turn to their broker to open a margin account, such as spread betting in order to trade over the counter. If UK investors intend to trade options, they need to qualify as members of Euronext, which is a separate platform.

Table 1.

Covered Warrants around the World

Panel A: Their Trading Values

Exchange	2002	2003	2004	2005	2006
	Total	Total	Total	Total	Total
Australian SE	1,729.7	1,633.7	2,810.4	4,985.9	7,311.4
BME Spanish Exchanges	1,061.6	1,830.0	2,273.8	2,654.4	3,675.7
Borsa Italiana	17,317.3	12,318.5	20,948.2	62,158.9	90,587.9
Deutsche Börse	26,468.1	45,987.9	107,599.2	170,516.1	285,854.8
Euronext	15,241.5	10,344.7	5,693.1	19,215.7	42,304.1
Hong Kong Exchanges	14,459.3	33,919.7	67,336.6	110,168.3	230,410.5
JSE South Africa	638.3	218.2	351.4	649.7	1,034.2
Korea Exchange	-	0.0	5.8	41.0	43,688.6
London SE	NA	419.7	813.8	609.9	1,346.4
Mexican Exchange	34.9	33.2	72.4	150.2	309.1
Singapore Exchange	23.2	14.4	931.1	6,521.2	9,155.7
Swiss Exchange	16,538.6	15,297.6	20,246.5	25,868.6	38,660.0
Taiwan SE Corp.	2,155.8	3,440.1	6,251.6	4,423.6	5,388.0
TSX Group	151.2	513.9	714.6	938.0	2,103.1

Panel B: Number of Listed Covered Warrants

Exchange	2002	2003	2004	2005	2006
	Total	Total	Total	Total	Total
Australian SE	1,201	1,395	1,771	2,447	3,091
BME Spanish Exchanges	1,509	1,056	1,308	1,344	2,627
Borsa Italiana	3,571	2,594	3,021	4,076	4,647
Deutsche Börse	18,059	21,431	46,627	69,457	129,954
Euronext	4,595	3,770	4,991	4,913	5,841
Hong Kong Exchanges	347	530	863	1,304	1,959
JSE South Africa	306	239	210	321	315
Korea Exchange	-	1	3	72	1,387
London SE	311	545	644	213	416
Mexican Exchange	11	3	13	26	22
Singapore Exchange	3	3	146	455	521
Swiss Exchange	3,511	2,662	3,682	6,246	10,369
Taiwan SE Corp.	102	272	191	540	694
TSX Group	27	44	60	66	76

This table presents the development of covered warrants after 2002, which can be called a stage of rapid growth and an era when covered warrants rose in popularity.

Source: World Federation of Exchange, table is conducted by the author

3. Previous Research and Hypotheses

3.1 Long-run relationship

One of the major lines of enquiry within the options literature examines the information linkage between options and their underlying assets (Stephan and Whaley (1990), Chan *et al.* (1993), Diltz and Kim (1996), O'Connor (1999)). Diltz and Kim (1996) confirm that there is a bi-directional price relation between options and their underlying shares. O'Connor (1999) confirms a cointegration relationship between shares and options: he claims that options lead the underlying shares.

That said there have as yet been no in-depth studies on the price linkage between covered warrants and their underlying shares in the UK, likely because this market only began trading six years ago. The UK covered warrants market and share market are traded simultaneously within the stock exchange. It is pertinent for us to claim that there may be a reciprocal price relationship between the two assets due to synchronous trading. The emergence of the covered warrants market may have led to improvements in terms of information transmission, which may suggest a long-run price relationship between the two assets.

***Hypothesis 1**: With the same underlying assets, if the market reacts to information efficiently, there is a long-run relationship between covered warrants and their underlying shares.*

3.2 Lead and lag relationship: *Synchronous trading hypothesis*

Our paper is the first attempt in the literature to access the lead and lag relation between covered warrants and their underlying shares. Manaster and Rendleman (1982), Jennings and Starks (1986), Bhattacharya (1987), and Diltz and Kim (1996) all document evidence that options lead their underlying stocks. Manaster and Rendleman (1982) claim that options are more informative, and therefore should lead their underlying shares. O'Connor (1999) finds an insignificant lead and lag relationship between options and their underlying shares. Also, Chatrath *et al.* (1995) show that an option-trading increase is followed by a negative change in cash market volatility; moreover, there is a bi-directional relationship between the two markets.

In contrast to the above findings, Stephen and Whaley (1990) and Chan et al. (1993) suggest that the stock market leads the options price. They claim that this results in investors using the options market solely as a return/risk management tool, rather than as a market to reflect new information. Chan *et al.* (1993) provide the private information hypothesis, suggests that the options market should lead the stock market because of its greater leverage. Further, the infrequent trading hypothesis suggests that the stock market should lead the options market because a thicker tick size makes the option price move more slowly. Fleming *et al.* (1996) suggest a trading cost hypothesis that the average trading cost in the stock market is lower than in the options market, but found mixed results in the lead/lag relationship between the options and the stock market. Finally, Easley *et al.* (1998) both suggest that, since the options market is the primary market for information, options lead stocks.

In this paper, we claim that, based on the institutional perspective in the UK, within the same trading venue and trading hours, if the market is efficient, there should not be a significant lead and lag relation between the two covered warrants the underlying shares if we apply daily data. This reflects one of the distinct differences between covered warrants and options – the previous options literature has proven unable to solve the problems related to synchronous trading and market segmentation due to reasons of legislation, but the covered warrants market does not experience these same difficulties; therefore, in this paper we propose the "*synchronous trading hypothesis*". We posit that, since the two financial instruments trade together on the London Stock Exchange, the market reacts to the information shock, so that there is no significant lead and lag relationship on a daily basis.

Hypothesis 2*: Due to the fact that UK covered warrants and their underlying shares are traded synchronically on the London Stock Exchange, there is no significant lead and lag relationship between the two assets on a daily basis.*

4. Data and Methodology

4.1 Data

The list of covered warrants was obtained from the London Stock Exchange and the covered warrant issuers' websites, with the majority coming from the SG (Societé Générale), which is currently the largest covered warrant issuer in the UK. In order to calculate the implied share prices for each corresponding underlying share, information is required about the covered warrant price series, parity ration, maturity, and strike prices. At least two covered warrants traded for the same duration are essential in terms of calculating the implied prices and implied volatility when we invert the Black-Scholes model. This paper data series of UK covered warrants and their underlying share price ranging from March 2005 and March 2007 were selected from the Datastream. In total, 191 covered warrants were obtained, such that estimations regarding the equilibrium share prices and implied standard deviation could be made. 71 implied stock price series were derived from inverting the Black-Scholes model; therefore, 71 paired samples were employed in our cointegration analysis. The sample set was comprised of 41 underlying shares listed on the London Stock Exchange. In addition, UK three month zero rates were selected from the Datastream as the interest rate in the pricing model. Furthermore, as covered warrant expiration dates approach, their prices typically drop dramatically due to decreases in the time value. We excluded the 25 days of trading statistics prior to the expiration of each covered warrant, and ensured that they were all matched with an underlying share series.[3]

4.2 Methodology

4.2.1 Calculation of the Implied Stock Price

Manaster and Rendleman's (1982) option-implied share price model to estimate the so-called implied share prices, S^*, as well as the implied volatility. To estimate the covered warrants' assessment of the equilibrium stock prices while preventing errors of measurement in

[3] Diltz and Kim (1996) excluded the 10 days of trading statistics prior to the option expiration; however, as covered warrants have longer periods to maturity as compared with options, we increased the period of exclusion to 25 days.

standard deviation, the implied volatility and implied prices were calculated simultaneously by including data from several covered warrants and their underlying shares, with the same duration and listing dates.[4] First the implied stock price, S_{jt}^*, and implied standard deviations, σ_{jt}^* for stock j at time t, were calculated, to solve the following problem:

$$(S_{it}^*, \sigma_{it}^*) = Arg \min_{S_{it}, \sigma_{it}} \sum_{j=1}^{N_{it}} [\, W^j - W^j(S_{it}, \sigma_{it}) \,]^2 \qquad (1)$$

where W^j is an observed covered warrant market price, $W^j(S_{it}, \sigma_{it})$ is the calculated Black-Scholes (theoretical) covered warrants price, and N_{it} is the number of covered warrants on security i at time t. The solution to Equation (1) minimises the sum of the squared deviations between the observed and calculated covered warrant prices.

4.2.2. Unit Root Tests and Panel Unit Root Tests

The Augmented Dickey-Fuller (ADF) test was employed to test the unit root. In order to select an adequate lag structure, the Akaike information criterion (AIC) was applied in this study.[5] Under a stable VAR system, the AR polynomial criterion found that only three of the 71 pairs of samples might not have been stable, allowing us to proceed with the VAR analysis.

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[4] Implied standard deviations have been investigated by Latané and Rendleman (1976), Trippi (1977), Chiras and Manaster (1978), Schmalense and Trippi (1978), and MacBeth and Merville (1979).

[5] Except for the AIC criterion, one can also choose either the SIC or LR tests to select the optimal lag structure.

As for the panel unit root test, Im *et al.* (1997, 2003) proposed the IPS test based on the average of ADF *t*-statistics in the following linear autoregressive model. To enhance the robustness, we further apply panel unit root test proposed by Hadri (2000). Nevertheless, the above tests do not account for cross section dependence. Therefore we adopt Pesaran (2007)'s test that allow for cross section dependence using orthogonalization type procedures to eliminate the cross dependence have been proposed in the literature.

The above three multivariate unit root tests can be expected to have low power if the time series contains a nonlinear type of dynamic (e.g. structural breaks). Hence, Cerrato *et al.* (2008) propose a nonlinear heterogeneous panel unit root test for testing the null hypothesis of unit root against the alternative that allows a proportion of the unit to be generated through an exponential STAR (ESTAR) process and a remaining non-zero proportion to be generated by a unit root process in the following model:

$$y_{it} = \beta_i y_{i,t-1} + v_i y_{i,t-1} Z(\theta_i; y_{i,t-d}) + \gamma_i f_t + u_{it}, \tag{2}$$

$$Z(\theta_i; y_{i,t-d}) = 1 - \exp(-\theta_i y_{i,t-d}^2),$$

where we assume that $\theta_i \geq 0$, and $d \geq 1$, is the delay parameter.

4.2.3 Lead / Lag relationship, Cointegration, and Panel Cointegration

Sims (1980) proposes a multivariate Vector Autoregressive model (VAR), in this study, the price series of both the covered warrants and the underlying shares can be endogenous because the information can be transmitted in either direction. Consider a VAR of order *p* (*p* is the optimal lags number according to the information criteria) with two non-stationary I(1) variables for the logarithm implied prices of the covered warrants and the logarithm underlying share prices[6]:

$$\begin{pmatrix} CW_t \\ US_t \end{pmatrix} = \sum_{k=1}^{p} \begin{pmatrix} A_{k11} A_{k12} \\ A_{k21} A_{k22} \end{pmatrix} \begin{pmatrix} CW_{t-k} \\ US_{t-k} \end{pmatrix} + \begin{pmatrix} A_{01} \\ A_{02} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} \quad (4)$$

where CW_t is the covered warrant implied price time series and US_t is the individual underlying share price series.

In order to examine the dynamic relationships between the two assets the vector error correction model (VECM) is presented in a matrix form, as follows:

$$\begin{pmatrix} \Delta CW_t \\ \Delta US_t \end{pmatrix} = \begin{pmatrix} \alpha_{cw} \\ \alpha_{us} \end{pmatrix} \left(\beta_{cw} \ \beta_{us} \ \mu \right) \begin{pmatrix} CW_{t-1} \\ US_{t-1} \\ 1 \end{pmatrix} + \sum_{k=1}^{p} \begin{pmatrix} \gamma_{k11} \ \gamma_{k12} \\ \gamma_{k21} \ \gamma_{k22} \end{pmatrix} \begin{pmatrix} \Delta CW_{t-k} \\ \Delta US_{t-k} \end{pmatrix} + \begin{pmatrix} \varepsilon_{cw,t} \\ \varepsilon_{us,t} \end{pmatrix} \quad (5)$$

where the ΔCW_t and the ΔUS_t terms are the differences of both the lagged price series. The coefficients α_{cw} and α_{us} represent the speed of adjustment to information shocks in the long

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6 Johansen (1988, 1991, 1992)

term. If we compare the *t*-statistics of α_{cw} to that of α_{us}, a significant *t*-statistic represents a lead position over the other assets. The matrices $\begin{pmatrix} \gamma_{k11} & \gamma_{k12} \\ \gamma_{k21} & \gamma_{k22} \end{pmatrix}$, k=1, …, p, indicate the short-run dynamic (lead and lag) relationship between the covered warrants and the underlying shares with various k lags.

To obtain a generalized result regarding the cointegration relation between the covered warrants and their underlying shares in the UK, panel cointegration analyses developed by Pedroni (1995, 2004) and Kao (1999) were employed. Kao (1999) proposes a pooling regression that allows for individual fixed effects to estimate the homogeneous cointegrating relationship. The regression is given by:

$$Y_{jt} = a_{0j} + \beta X_{jt} + u_{jt}, \qquad (6)$$

where β and X_{jt} are row and column vectors, respectively, u_{jt} is a regression error, and j denotes either the underlying share price, or the covered warrant implied price. The LSDV estimator for β is denoted $\hat{\beta}$. The residuals from this first-stage regression:

$$\tilde{u}_{jt} = (y_{jt} - \bar{y}_{jt}) - \tilde{\beta}(X_{jt} - \bar{X}_{j})$$

still contain a unit root under the null hypothesis of no cointegration. Also, a pooled Dickey Fuller (DF) regression is presented:

$$\Delta\tilde{u}_{jt} = (\rho - 1)u_{j,t-1} + v_{it}$$

where the pooled ordinary least squares (POLS) estimator of $(\rho - 1)$ is denoted by $(\tilde{\rho}$-1).

Kao (1999) tests are based on $\tilde{\rho}$ and the corresponding t-statistic, denoted t_ρ.

To enhance the robustness, we further apply panel unit root test proposed by Pedroni (1995, 2004). All test statistics were implemented as residual tests. The null hypothesis for the panel cointegration tests of Pedroni (1995, 2004) and Kao (1999) was that the estimated equation is not cointegrated; H_0: i=1 (i.e. no cointegration) for all cross-sectional units.

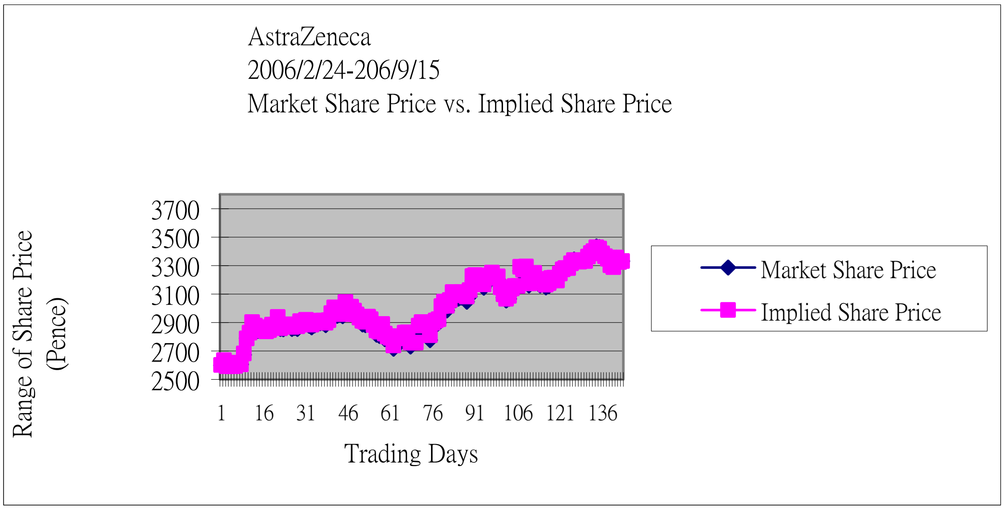
5. Empirical Findings and Analysis

5.1 Data description

Graph 1 uses Astra Zeneca and Standard Charted Bank as examples to document the patterns of the implied share prices and the actual underlying share prices during the covered warrant trading period. This result indicates that the UK covered warrants can serve as an assessment in terms of estimating the equilibrium share market prices, suggesting confirmation for Hypothesis 1.

Figure 1.

Implied Share Price Inverted from the Covered Warrants Market Price According to the Black-Scholes Model vs. Actual Share Market Price



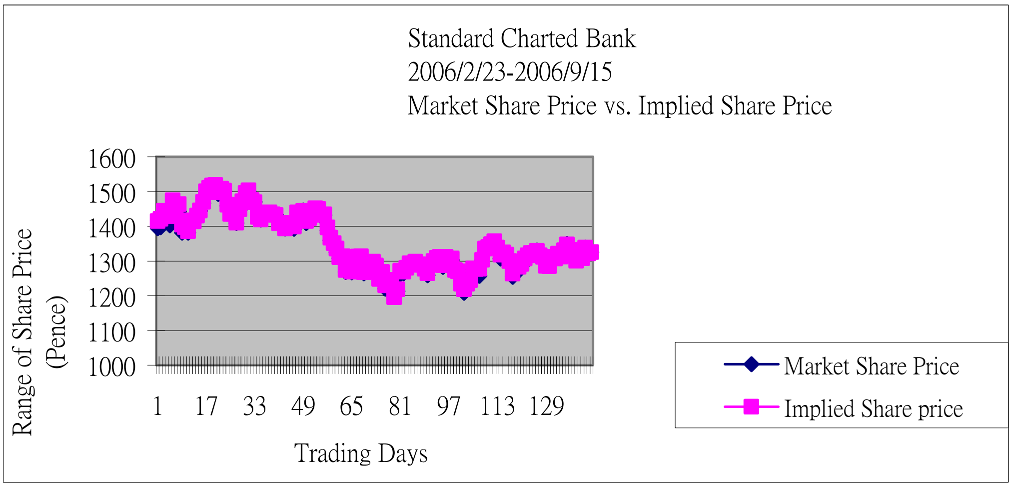


Figure1 takes Astra Zeneca and Standard Charted Bank as examples to document the patterns of the implied share prices and their underlying share prices during the covered warrant trading period. One can observe that the calculated implied share prices show a high degree of consistency with the actual underlying share market prices.

Figure is conducted by the authors.

5.2 Cointegration test and the VECM short term dynamics under VAR

Table 2 addresses the results of the pairwise cointegration analysis. Results in Panel A shows that 89% of the samples generated a significant cointegration relation between the implied stock price and the underlying share, indicating a strong long-run equilibrium between the covered warrants and the stock. This confirmed hypothesis 1.

Panel B in Table 2, reports the results of the short-term dynamic of the cointegrated pairs. The results of the VECM mechanism shows 3 of the 63 cointegrated series presented significant statistics regarding the stock price leading the covered warrant price in the level degree; whereas 2 pairs showed the covered warrant leading the underlying share in the level degree. Further, seven pairs showed that the implied share prices and the underlying share market prices led each other at the same level, which was equal or greater than one lag. The remaining 51 cointegrated pairs showed that under the VECM model, the implied share prices reflected new information simultaneously with the underlying shares, while the two price series also obtained a long-term equilibrium. The empirical findings confirm our second hypothesis regarding synchronic trading – due to the fact that UK covered warrants and the underlying shares are traded synchronically on the London Stock Exchange, there is no significant lead and lag relationship between them on a daily basis.

Table 2. Pairwise cointegration analysis

Panel A: The unrestricted cointegration rank test, the trace tests

Distribution by No. of Significant cointegration		
The Trace test of each pair	**No. of pairs**	**Percentage of Sample**
Significant at 10 % level	63	89%
Insignificant	8	11%

Panel B: The Vector Error Correction Model

Lagged lead and lag relationship under the VECM model		
The lead lag relation	**No. of pairs**	**Percentage of Sample**
Lagged ln△tw affect ln△cw *significant* $\gamma 12_i$	3	4.8%
Lagged ln△cw leads ln△tw *significant* $\gamma 21_i$	2	3.1%
Feedback relations *significant* $\gamma 12_i$ *and* $\gamma 21_i$	7	11.1%
Feedback relations at level (no lead-lag relation but cointegrated)	51	81%

Table 2 addresses the results of the pairwise cointegration analysis. Results show that 89% of the samples generated a significant cointegration relation between the implied stock price and the underlying share, indicating a strong long-run equilibrium between the covered warrants and the stock. This confirmed hypothesis 1. 51 cointegrated pairs showed that under the VECM model, the implied share prices reflected new information simultaneously with the underlying shares, while the two price series also obtained a long-term equilibrium.

5.4 Unit Root and Panel Unit Root Tests

The univariate ADF test applied to all series showed that they were all unit root nonstationary series. When the ADF test was applied to the first difference of the series, it was found that they were all I(0) stationary series.

Table 3 shows the results of panel unit root tests. The 71 pairs of underlying shares with the corresponding implied prices inverted from the covered warrant market prices were used to compute the IPS tests and the Hadri (2000) test. Since most of the individual time series displayed one to eight lags, we included eight lags in the panel. Consequently, to get an oblong panel, the 92 last observations were selected for each series. Results from the IPS (1995, 1997, 2003) tests and Hadri (2000) tests confirmed that there was a unit root for both the underlying share market prices and the implied market price.

Furthermore, the Pesaran (2007) test and the Cerrato et al. (2008) test were conducted to further account for cross-sectional dependence and nonlinear heterogeneity. To apply these two panel cointegration tests, the time period is required to be the same for each series, which permits us to account for cross-sectional dependence by estimating the common (time) component in the panel. However, the time period was not the same for each series of implied prices, the beginning and the end of the series were eventually truncated so that the time period was the same for each series. Hence, three subsample periods were employed; the first one covered from 24/02/2006 to 15/09/2006, the second from 2/11/2006 to 15/03/2007, and the last from 11/04/2005 to 16/09/2005. The results for the most recent tests in the literature that do account for a cross-sectional dependence are very clear: they retain the hypothesis of unit root for all time series. Further, the panel unit root tests applied to the panel of first differences of the series found that the first differences of the series were I(0).

5.5 Panel Cointegration tests

In this subsection, we used the Gauss package NPT 1.3 from Chiang and Kao (2000) to compute the Pedroni (1995, 2004), and the Kao (1999) tests. The cointegration tests were applied to the same panels of underlying shares and their corresponding implied share prices (implied from the warrant prices) as for the panel unit root tests lacking cross-sectional dependence. The results are presented in Table 4. We can conclude that the underlying share prices were cointegrated with their corresponding implied share prices; this again confirms the empirical results for the individual pairwise test and also supports Hypothesis 1 – *with the same underlying assets, if the market reacts to the information efficiently, there exists a long-run relationship between covered warrants and their underlying shares.*

Table 3
Results for the Panel Unit Root tests

Panel A. On the Underlying share price series

Test	Specification	Null	Number of	Test	P value
IPS 1995	Time trend	Unit roots	**8**	0.9990	0.1589
IPS 1997 t	Time trend	Unit roots	**8**	1.0251	0.1527
IPS 1997 $\overline{LM}$	Time trend	Unit roots	**6**	-1.1066	0.1342
Hadri (2000)	Time trend	Stationarity	**8**	3263.6937	0.0000*
Subsample 1					
Pesaran (2005)	Time trend	Unit roots	**8** [b]	-1.4320	0.9980
Cerrato et al.	Time trend	Unit roots	**8** [b]	-1.7630	0.9290
Subsample 2					
Pesaran2005	Time trend	Unit roots	**8** [b]	-1.6960	1.0000
Cerrato et al.	Time trend	Unit roots	**8** [b]	-1.5580	1.0000
Subsample 3					
Pesaran2005	Time trend	Unit roots	**8** [b]	-2.2000	0.7870
Cerrato et al.	Time trend	Unit roots	**8** [b]	-1.9200	0.9180

Panel B. On the implied price series inverted from covered warrants prices

Test	Specification	Null	Number of	Test	P value
IPS 1995	Time trend	Unit roots	**4**	0.1692	0.4328
IPS 1997 t	Time trend	Unit roots	**4**	0.3011	0.3816
IPS 1997 $\overline{LM}$	Time trend	Unit roots	**4** [a]	-3.3564	0.0004 *
Hadri (2000)	Time trend	Stationarity	**8** [b]	2906.4277	0.0000
Subsample 1					
Pesaran (2005)	Time trend	Unit roots	**8** [b]	-1.6280	0.9930
Cerrato et al.	Time trend	Unit roots	**8** [b]	-1.6930	0.9530
Subsample 2					
Pesaran2005	Time trend	Unit roots	**8** [b]	-1.6750	1.0000
Cerrato et al.	Time trend	Unit roots	**8** [b]	-1.6700	1.0000
Subsample 3					
Pesaran2005	Time trend	Unit roots	**8** [b]	-1.9730	0.9620
Cerrato et al.	Time trend	Unit roots	**8** [b]	-1.6110	0.9970

[a] the variance matrix is singular for 5 and more lags. Consequently 46 lags are chosen.

[b] The null hypothesis is retained for all the lag numbers, from 0 to 8.

* Test significant at 5% level.

Table 4
Results for the panel cointegration tests

Test	Null hypothesis	Number of lags	Test statistic	P value
Pedroni (1995,2004)	The time series are Not cointegrated			
$-t_p(N,T)$			-2206.9546	0.0000 *
$-TN1_p$			-119.1410	0.0000 *
$-TN2_p$			-118.3648	0.0000 *
Kao (1999)	The time series are Not cointegrated			
$-DF_p$ *Test*			-46.3532	0.0000 *
$-DF_{t,p}$ *Test*			-19.5034	0.0000 *
$-DF_p^*$ *Test*			-87.7352	0.0000 *
$-DF_{t,p}^*$ *Test*			-15.4925	0.0000 *
$-ADF$ *Test*		3 **	-3.3408	0.0004 *

* Test significant at 5% level.
** The number of lags is determined by the AIC. Nevertheless, the null hypothesis is rejected at 5% for all the number of lags up to 12, except for 6, and 7 lags.

6. Conclusions

This paper contributes to the literature by representing the first attempt to examine the UK covered warrants market. The invention of covered warrants provides convenient access for individual market participants to construct a hedging and speculation position in their portfolio while negating the complexities associated with qualifying as a member of the options market. From recent market trading statistics, we can observe that the growth of the covered warrants market around the world has been significant, and there is urgent need for an in-depth study of this financial instrument. In this paper, we claim that the price interaction between UK covered warrants and their underlying shares should be scaled, in the sense that both assets convey information related to the underlying firm – covered warrants may carry an information role. This study also attempts to offer a comprehensive approach by calculating the inverted covered warrant price as an implied share market price.

Further, this paper attempts to find an information linkage between covered warrants and their underlying shares. With a large sample set and a varied methodology, it is hoped that the results contribute to the current knowledge regarding the price discovery function, and confirm the information linkage between the covered warrant market and the underlying share market in the UK. With synchronic trading on the same platform, covered warrants and their underlying shares simultaneously react to the same information.

In conclusion, this paper investigates one of the fastest growing derivative instruments in the developed UK capital market. Stimulated by the fact that a knowledge gap exists between academics and practitioners in terms of their understanding of these relatively new financial derivatives, covered warrants, we propose several methodologies to test the long run relation, short term dynamics, and information transmission between the two related assets. The empirical results are consistent with the hypotheses, and further suggest that synchronic trading in UK leads to speedy arbitrage opportunities. Furthermore, a clearer consensus over the short run dynamics between the two instruments may prove possible by further applying high frequency data (*i.e.* intraday data) in the future.

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