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Relationship between macroeconomic variables and net asset values (NAV) of equity funds: Cointegration evidence and vector error correction model of the Hong Kong Mandatory Provident Funds (MPFs)

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ABSTRACT

This paper is the first to examine the cointegration and causality among the net asset values (NAV) of Hong Kong equity funds under the Hong Kong Mandatory Provident Fund (MPF) scheme, the local stock market index – Hang Seng Index (HSI), and selected Hong Kong macroeconomic variables including the inflation rate proxied by CPI, money supply (M2), and short-term interest rate proxied by overnight Hong Kong Interbank Offer Rate (HIBOR), during the period 2001–2009. Bivariate cointegration analysis indicates that the fund NAV respond to HSI and CPI, but not respond to M2 and HIBOR; while multivariate cointegration analysis adds further evidence that the fund NAV are cointegrated with a set of these macroeconomic variables. The fund NAV is found to be Granger caused by HSI, CPI, and M2; however, HIBOR does not have any Granger causal relations with the fund NAV. A multivariate error correction model (ECM) of each fund's NAV on all macroeconomic variables is finally constructed, which adds further evidence that fund price is not causal related with HIBOR. This suggests that any movements in selected macroeconomic variables can be used to predict the movement of NAV and the MPF scheme participants may ignore the effects of changes in interest rates on the changes in NAV when they consider reallocating the distribution between equity funds and other types of funds.

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1. Introduction and previous research

Like many other countries, Hong Kong has an aging population – where people aged 65 and above accounted for only 6.6% of the population in 1981; by 2003, this figure had risen to 11.5% and it is expected to increase to 14% by 2016 and to 24% by 2031. The government is grappling with the policy implications of how best to provide for the retirement needs of this ever increasing group. The first major policy initiative has been the introduction of the Mandatory Provident Fund (MPF) system, which was implemented on 1 December 2000. Under this scheme, most employees and their employers are required by law to make monthly contributions to a MPF, which are based on the level of salary and the period of employment. These MPFs are managed by approved private organizations according to criteria set out by the government. Prior to the implementation of the MPF system, only one-third of the 3.4 million Hong Kong workforce had some form of retirement protection, and with the introduction of the MPF system, this figure had risen to 86% by the end of 2001.

It is an important empirical issue to identify whether these funds are able to provide a reasonable rate of return to the investors whose future welfare depends so much on their performance. The literature on the performance of mutual funds is extensive in these several decades and many of these studies compare the fund's return with that of the market. Most of them confirm the inability of mutual funds to outperform the market benchmarks or indices (Jensen, 1968; Lehmann and Modest, 1987; Grinblatt and Titman, 1989; Malkiel, 1995; Gruber, 1996; Carhart, 1997). The findings of the studies on performance of mutual funds traded in other countries are consistent with the U.S. evidence (Cai et al., 1997; Hallahan and Faff, 1999; Sawicki and Ong, 2000; Bauer et al., 2006).

The launch of the MPF system has created an entirely new class of asset in the Hong Kong financial market, which has a very broad base of investor support. These funds represent the cornerstone of the government's policy to deal with the financial burden of the retired population. Given their importance and investor interest in these funds, there is a need for research on the performance of MPFs. The scheme participants and the practitioners may desire to determine which economic changes may have influence on the NAV of MPFs.

The primary objective of this research is to add further evidences that some macroeconomic variables such as inflation rate, interest rate and money supply, which have been found to have a great influence on stock returns in literatures, are cointegrated and have causality with the price levels of MPF equity funds. The mutual fund investors or the MPF scheme participants always have to judge the allocation of their investments in different funds by buying, selling or switching between funds. They should have strong desire to know which economic factors may affect their mutual fund returns. This research may find the influence of different macroeconomic variables on the MPF Hong Kong equity fund NAV and this may enhance the scheme participants' ability in predicting NAV of equity funds by paying attention on the changes in the macroeconomic variables on top of observing the climate of stock market.

Correlations measure the comovement of two variables, while cointegration analysis tests whether two time series tend to move together with time without deviating from each other and maintaining a long-run equilibrium state. The presence of cointegration indicates the existence of long-term equilibrium relationship between the variables. The Granger causality test may reveal which time-series variable is exogenous and which time-series variable is endogenous. The causality test may analyze the causal relationship between the variables discussed and study whether the variables cause the MPF price levels to increase or decrease. There are extensive studies on the relation between the macroeconomic variables mentioned above with the market return and stock price respectively.

First of all, inflation rates, both expected and unexpected, are found to be negatively correlated with market return in most studies. Evidences of negative relation between the inflation and stock market returns in the U.S. are documented (Jaffe and Mandelker, 1976; Bodie, 1976; Fama and Schwert, 1977; Geske and Roll, 1983; Chen et al., 1986; Marshall, 1992). Hamao's (1988) study on the Japanese stock market is consistent with the evidences in the U.S. The recent studies focus on using cointegration analysis which tests whether two time series tend to move together with time without deviating from each other, rather than using correlation which measures the comovement of two variables. Bulmash and Trivoli (1991) indicate that CPI is spuriously related with the stock prices. Mukherjee and Naka (1995) employ the Johansen's (1991) cointegration analysis and find that the Tokyo Stock Exchange

(TSE) index movement is negatively cointegrated with the changes in Japanese inflation. Maysami and Koh (2000) add evidence of negative cointegration between the inflation and Singaporean stock market returns. However, Abdullah and Hayworth (1993) find that Standard & Poor's 500 stock price index return and inflation rate are positively related. Nasseh and Strauss (2000) also indicate similar results of the existence of positive cointegration between inflation and stock prices in six European countries: France, Italy, Netherlands, Switzerland, U.K., and Germany. Ibrahim and Aziz (2003) and Ibrahim (2003) also find a similar result in Malaysian stock market, in which index KLCI (Kuala Lumpur Composite Index) is found to be positively cointegrated with the Malaysian CPI. Aside from evidences of either positive or negative cointegration between inflation and stock market return are found, evidences of causality are found between these two time series. Bulmash and Trivoli (1991) show that CPI is spuriously related to stock prices. Ibrahim (1999) documents that the end-of-the-month stock prices in KLCI are Granger caused by the consumer prices, changes in the official reserves and exchange rates in the short run. Dritsaki (2005) adds the evidence of existence of unidirectional causal relationship from the inflation rate to the General Index of Athens Stock Exchange. Regarding the other type of investment vehicle, Real Estate Investment Trusts (REITs) is expected to be unable to hedge against inflation; however, empirical evidence shows that REITs may hedge inflation (Goebel and Kim, 1989; Park et al., 1990; Chen et al., 1990; Liu et al., 1997; Lu and So, 2001).

Money supply is the other macroeconomic variable has been found to be one of the factors that may explain the stock market return or stock price. However, the relationship between money supply and stock market return is found controversial in different markets. The money supply is found to be positively correlated with stock price in U.S. (Palmer, 1970; Rudolph, 1972; Homa and Jaffee, 1971). Evidence of positive cointegration between the changes in money supply and stock prices are found in literatures. Habidullah (1998) also documents strong positive correlation and the existence of long-run cointegration between money supply (defined as M1 or M2) and stock prices in Malaysian stock market. Bulmash and Trivoli (1991) document the presence of positive cointegration between the stock prices in U.S. and money supply changes. Mukherjee and Naka (1995) and Brown and Otsuki (1990) find consistent findings in Japan. Thornton (1998) indicates that real stock prices in Germany have a significant and positive relationship on the long-run demand for real money balances defined as M1. Maysami and Koh (2000) also find positive but insignificant cointegration between Singaporean stock prices and money supply. Ibrahim (2003) finds a similar result in that the Malaysian stock prices are positively cointegrated with money supply M1. However, Kwon and Shin (1999) find a contract result which indicates that the stock prices in Korean stock market are negatively cointegrated with money supply. Ibrahim and Aziz (2003) also document the presence of negative cointegration between stock prices in Malaysian Stock Exchange and the local money supply if it is defined as M2. Regarding causal relationship, Hashemzadeh and Taylor (1998) indicate the money supply and stock prices are bidirectional causal related.

Interest rate is found to be one of the key determinants of stock prices or market returns in literatures and most of the studies document evidence of negative relationship between the interest rate and the stock prices, which is consistent with the theory in finance. Abdullah and Hayworth (1993) find that S&P500 returns are more closely related to the long-term interest rate than the short-term rate. Bulmash and Trivoli (1991) also observe a similar negative relation between long-term Treasury rate and stock prices for the U.S, as well as Maysami and Koh's (2000) findings in Singapore. Mukherjee and Naka (1995) find a mixed relation result between the Tokyo stock market return and the interest rates; they find a normal negative relationship between the long-term government bond rate and the market return, but a controversial positive relation between the short-term call money rate and the return is found. Nasseh and Strauss (2000) find a similar mixed result in six European markets; positive cointegration between the stock prices and short-term interest rate but a negative cointegration between the stock prices and long-term interest rate are found. Looking at the causal relationship, Abdullah and Hayworth (1993) document the existence of Granger causality between the interest rates and the stock prices, which is consistent with Thornton (1998) and Taylor (1998). Dritsaki (2005) add evidence of unidirectional causal relationship from interest rates to the General Index of Athens Stock Exchange.

The study on the relationships between mutual fund returns and the macroeconomic variables mentioned previously is not extensive. Lu and So (2001) findings show that inflation does not Granger-cause REITs returns but REITs returns reflect changes in monetary policy proxied by changes interest rates through a vector error correction (VEC) model. Fadhil et al. (2007) suggest that NAV of unit trust in Malaysia has a long-run relationship with the macroeconomic variables including KLCI index, M2 and CPI by adopting an error correction model (ECM). Avramov et al. (2011) find that incorporating the default spread and the VIX is important to predict the managerial alpha, fund betas, and benchmark returns of hedge funds when forming optimal portfolios.

The mutual funds' NAV are found to have causal relation with the local stock market index. Chang et al. (1995) document the existence of cointegration between the U.S. stock market index and the net asset value for the majority of closed-end country funds from North America and Europe. However, there is no evidence of cointegration between these two time series for Asian emerging markets such as India, Korea, Malaysia, Taiwan and Thailand. Ben-Zion et al. (1996) find that the three foreign country funds which include Germany, U.K., and Japan listed in the U.S. stock market are not cointegrated with but have causal relation to their national stock markets. Matallin and Nieto (2002) document little evidence of cointegration between the mutual funds and the Spanish stock market index Ibex 35. Chu (2010) documents that 56.43% of the equity funds authorized to be included in Hong Kong MPF schemes have their price levels cointegrated with stock market index. In the short run, the Granger causality test indicates that some funds' price levels have both long- and short-run comovements with the stock market indices; on the other hand, some equity funds are found to have short-run comovements with the stock market index but no long-run comovements with the index, this indicates that some equity fund managers have ever attempted to design their portfolios trying to win the market.

To limit the scope of this study, only Hong Kong equity funds that are authorized by the Mandatory Provident Fund Scheme Authority to be included in the MPF scheme and have at least four years of operations are considered. Furthermore, mutual funds that are not included in MPF scheme are excluded even though some of them are authorized by the Hong Kong Monetary Authority to sell in the territory. The focus on pension funds to the exclusion of other types of funds is based on the observation that pension fund managers control a larger portion of the aggregate wealth than do mutual fund managers (Coggin et al., 1993).

The rest of the paper is organized as follows. Section 2 describes the data and research methodology employed. Section 3 discusses the findings and the concluding remarks are summarized in Section 4.

2. Research methodology and data

2.1. Methodology

2.1.1. Unit root test

Prior to the causality test, we have to certain that the time series are stationary. A time series is said to be stationary if its mean and variance are constant over time and the value of the covariance between the two time periods depends only on the distance or gap or lag between the two time periods and not the actual time at which the covariance is computed. If the time series is nonstationary, the deflection from the mean will be permanent. A time series is said to be $I(0)$ if it is stationary at the level form. A time series is said be integrated of order d if it has to be differenced d times to make it stationary. For example if a time series is $I(2)$, then $\Delta\Delta Y_t = Y_t - 2Y_{t-1} + Y_{t-2}$ will be stationary. The unit root test based on the augmented Dickey–Fuller (ADF) test, which is a widely popular used methodology to examine the presence of stationary in the time series, will be first performed. The augmented Dickey–Fuller test may be used regardless the error term u_t are correlated or not. The augment is conducted by adding the lagged values of the dependent variable ΔY_t. According to Dickey and Fuller (1979, 1981), ADF test consists the following OLS estimation:

$$\Delta Y_t = \beta_0 + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + u_t \tag{1}$$

where u_t is the pure white noise error term and where $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$, etc. The optimal number of lagged difference terms to be included (m) is determined by Akaike's Information Criteria (AIC) which determines the optimal choice of lag length such that the autocorrelations in the error term may be removed (Akaike, 1970). The unbiased estimate of the coefficient of lagged Y_{t-1} δ can be obtained then. The null hypothesis in ADF, $H_0 : \delta = 1$, indicates the time series is nonstationary will be tested against the alternative hypothesis, $H_a : \delta < 1$. The ADF test follows the asymptotic distribution as the DF statistic.

2.1.2. Cointegration test

Once the order of integration is determined for each series, we may proceed to the second step to evaluate the cointegration properties of the variables. Cointegration test is to see whether the NAV or simply the price levels of MPF funds and the stock market index are individually nonstationary but become stationary when they are linearly combined. Two time series are said to be cointegrated if they have a long-term or equilibrium relationship although they may deviate momentarily from each other in the short run. That is, they cannot drift farther away from each other arbitrarily. Cointegration between the fund NAV and the economic variables suggests that the two series share the same common trend so that the regression of one on the other will not be necessarily spurious, and the fund NAV will be subject to the deviation from the economic situation. To test for cointegration, two of the most commonly used tests will be employed – the residual-based test of Engle and Granger (1987) and the maximum likelihood approach of Johansen (1988) and Johansen and Juselius (1990).

Following Engle and Granger (1987), the possible presence of cointegration may be tested by using Dickey–Fuller (DF) test on the error term, u_i from the following regressions:

$$\mathrm{MPF}_t = \beta_0 + \beta_1 X_t + u_t \tag{2}$$

and

$$\Delta u_t = -\theta \cdot u_{t-1} \tag{3}$$

where X_t indicates the time series of macroeconomic variables chosen to test for cointegration with the fund NAV, MPF_t indicates the time series of price levels of fund NAV and $\Delta u_t = u_t - u_{t-1}$. Eqs. (2) and (3) are generally known as Engle–Granger (EG) test, which is a two-step procedure involving an OLS estimation of a cointegrating regression (Eq. (2)) to obtain the residuals and a unit root test of the residuals (Eq. (3)). The null hypothesis in EG test, $H_0 : \theta = 0$, indicates the residuals in Eq. (2) are nonstationary and implies the two time series X_t and MPF_t are not cointegrated, will be tested against the alternative hypothesis, $H_a : \theta < 0$. Since the cointegration presumes the individual time series is nonstationary, the EG test is conducted on the price level data. Practically, the fund manager may have different portfolio or trading behavior from that of the market, but we should expect that the managers may react by changing the portfolio that is in line with the market, and which makes the series cointegrated.

The other approach to evaluate cointegration is Johansen–Juselius (JJ) approach which is a VAR-based test. While EG test tests for cointegration in a single-equation framework, JJ method allows testing for cointegration in a system of equations. The JJ method does not require a specific variable to be normalized and gives more efficient estimators of cointegrating vectors (Philips, 1991). The two statistics developed in this approach to determine the number of cointegrating vectors are trace statistics and maximal eigenvalue (Johansen and Juselius, 1990). They are based on a canonical correlation analysis of residuals from two vector autoregressions: (1) ΔY_t on $\Delta Y_{t-1}, \ldots, \Delta Y_{t-p+1}$ and (2) Y_t on $\Delta Y_{t-1}, \ldots, \Delta Y_{t-p+1}$, where Y_t is a vector of the variables involved and p is the order of autoregression. Johansen and Juselius (1990) compute the critical values of the test and Osterwald-Lenum (1992) recalculates the critical values for higher dimensions.

2.1.3. Granger causality

The last stage in our analysis is to specify the dynamic interactions of the variables. The Granger's causality test will be finally performed to examine if the indication of presence of cointegration may be due to error correction model; and to determine the presence of short-term relationship in the case that the time series are found to be not cointegrated. If any pair of series is not cointegrated, the following VAR model will be adopted to test for one-way causality, by running a regression of fund price levels on past values of the price levels and the macroeconomic variable as follow:

$$\Delta \text{MPF}_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i \Delta X_{t-1} + \sum_{j=1}^{m} \beta_i \Delta \text{MPF}_{t-j} + \varepsilon_i \tag{4}$$

Testing one-way causality is based on the logic that the fund mangers should usually change their portfolios to react the changes in the market; on the other hand, the index will not react by returning towards the funds. The optimal choice of lag terms is also determined by the AIC. A unidirectional causality from *X* to *Y* is indicated if the estimated coefficients on the lagged *X* in Eq. (4) are statistically significant as a group and it may be indicated by the following *F*-statistic:

$$F = \frac{(\text{SSR}_R - \text{SSR}_{\text{UR}})/m}{\text{SSR}_{\text{UR}}/(n-k-1)} \tag{5}$$

where SSR_R is the sum of squares of residuals of the restricted regression which assumes all the coefficients equal zero, SSR_{UR} is the sum of squares of residuals of the un-restricted regression or those of the original regression. The *F*-statistic follows the *F*-distribution with m and $n-k-1$ degrees of freedom. The presence of unidirectional causality implies the MPF fund managers are responding to the past changes in the market index in the short run.

2.1.4. Error correction model (ECM)

Engle and Granger (1987) indicate that the following causality test with ECM, Eq. (6) is preferable to Eq. (4) if cointegration is diagnosed to be existing between two time series:

$$\Delta \text{MPF}_t = \alpha_0 + \gamma \text{EC}_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta X_{t-1} + \sum_{j=1}^{m} \beta_i \Delta \text{MPF}_{t-j} + \varepsilon_i \tag{6}$$

where ε_t is the residual term from Eq. (6), EC_{t-1} is the equilibrium errors or the residuals of the cointegrating equations, lagged one period, and γ is the coefficient of the error correction term. Granger (1988) indicates that within the ECM, causality may arise from the lagged differences and from the error correction term. The lagged differences of the variables may capture the short-term dynamics and the tests of causality may be carried out based on the significance of these terms. The hypothesis involves two joint-hypothesis test: the coefficients of lagged variables and the error correction term are jointly zero. Note that, the changes in the fund NAV will depend not only on the changes in the macroeconomic variable but also on the long-run relationship between them, which allows for any previous disequilibrium measured by the error correction term EC_{t-1}, to exert potential influences on the movement of the fund NAV. The significance of the error correction term in each equation shows the tendency of each variable to restore equilibrium in the fund NAV. Toda and Philips (1994) supplemented that ECM may combine the short-run dynamics and long-run adjustment of the series, introducing two channels of causality from the macroeconomic variable to the fund NAV. This study only investigates the unidirectional causality of the macroeconomic variables to fund NAV, the reverse causation from the fund NAV to macroeconomic variables evaluated by reversing the roles of the dependent variable and independent variables will not be tested. Since the results of the test are sensitive to the selection of lag length, AIC is adopted again to determine the appropriate lag length.

2.2. Data

The data used in this study consists of monthly NAV of all 27 MPF constituent Hong Kong equity funds which have at least four years of operations, from the launch of MPF scheme on 1 December 2000 or the date of the introduction of the fund to 31 December 2009, giving a maximum total of 109 monthly observations. The names of these funds are summarized in the second column of Table 1. All of these data were provided by Lipper Asia Limited. The NAV of the equity funds is reduced by the exact amount of dividends or capital gain distributions paid to the shareholders. Thus, the monthly NAV in the database have been adjusted and are inclusive of these distributions. Most previous studies suggest

Table 1
Tests for unit roots in the prices and first difference of MPF equity funds and macroeconomic variables.

No.	Fund name	Price level		First difference	
		No trend	Trend	No trend	Trend
Panel A					
1	AIA-JF MPF Scheme – HK Equity	−0.7413	−2.6115	−7.8617*	−7.8197*
2	AIA-JF Premium MPF – HK Equity	−0.7159	−2.6213	−7.8462*	−7.8049*
3	AXA-Elite MPF-Multi-Manager HK Equity	−1.5467	−1.7174	−5.9834*	−5.9355*
4	Bank Consortium MPF – HK Equity	−1.2513	−1.5185	−7.8819*	−7.8401*
5	Bank Consortium Industry – HK Equity	−1.2514	−1.5184	−7.9114*	−7.8700*
6	BEA (MPF) HK Growth Fund	−1.4139	−1.3664	−5.6216*	−5.5679*
7	BOC-Prudential Easy-Choice MPF S – HK Equity	−1.5030	−2.2688	−7.2547*	−7.2279*
8	Fidelity Retirement MT – HK Equity	−0.6504	−3.0532	−8.1865*	−8.2323*
9	Fortis Master Trust MPF – HK Fund	−1.4300	−2.7046	−5.2332*	−5.2140*
10	HSBC MPF – Super Trust Plus – HK & China Equity	−1.3898	−2.8286	−5.2131*	−5.2136*
11	Hang Seng MPF – Super Trust Plus – HK & China Equity	−1.3898	−2.8286	−5.2131*	−5.2136*
12	HSBC MPF – Super Trust – HS Index Tracking	−0.7748	−2.7360	−8.4345*	−8.4529*
13	Hang Seng MPF – Super Trust – HS Index Tracking	−0.7748	−2.7360	−8.4345*	−8.4529*
14	HSBC MPF – Super Trust Plus – HS Index Tracking	−0.7748	−2.7360	−8.4345*	−8.4529*
15	Hang Seng MPF – Super Trust Plus – HS Index Tracking	−0.7748	−2.7360	−8.4345*	−8.4529*
16	ING MPF MT Basic – HK Equity Pf	−0.7494	−1.9938	−9.2962*	−9.2790*
17	ING MPF MT Comprehensive – HK Equity Pf	−0.7494	−1.9938	−9.2962*	−9.2790*
18	INVESCO Strategic MPF S – HK and China Equity	−1.3171	−1.5877	−7.8048*	−7.7666*
19	Manulife Global Select MPF – HK Equity	−0.9401	−2.0412	−8.7210*	−8.7070*
20	Mass MPF Scheme – HK Equity	−1.0239	−1.1432	−3.8931*	−3.8291*
21	Principal MPF Scheme S800 – HK Equity	−1.4559	−1.4751	−4.9251*	−4.8747*
22	Rainbow 65 – Sun Life MPF First State HK Equity	−0.8856	−2.8478	−4.9905*	−5.0077*
23	RCM MPF Plan – RCM HK Fund	−0.9252	−2.2381	−6.2486*	−6.1985*
24	Standard Chartered MPF – Adv – Legg Mason HK Equities	−0.7566	−2.6012	−8.7833*	−8.7545*
25	Standard Chartered MPF – Adv – HSBC MPF A – HK & China Equity	−1.4161	−2.8601	−5.2014*	−5.2074*
26	Schroder MPF MT – HK Portfolio	−0.4499	−2.4503	−8.3254*	−8.3297*
27	Taifook MPF Retirement Fund – HK SAR	−1.1878	−2.7224	−4.8995*	−4.8948*

Macroeconomic variables	Price level		First difference	
	No trend	Trend	No trend	Trend
Panel B				
Hang Seng Index	−0.9484	−2.2412	−8.5898*	−8.6129*
CPI Composite Index	−0.1095	−1.7030	−10.2926*	−10.9232*
M2	0.6375	−2.5119	−10.0374*	−10.1998*
Hong Kong Interbank Offer Rate (HIBOR)	−2.6018	−2.4958	−13.2169*	−13.1846*

* Indicates significant at 5%; the critical values of the ADF tests are developed by McKinnon (1996).

that using monthly data for mutual fund performance studies is appropriate as their distribution is closer to normal than the distribution of daily returns.

The monthly data of local stock market index, Hang Seng Index (HSI), are provided by the Hang Seng Indexes Company Limited. The monthly data of HK Composite CPI which proxies the inflation rate in Hong Kong are provided by the Hong Kong Statistics and Census Department. The monthly data of money supply and overnight HIBOR are provided by the Hong Kong Monetary Authority.

3. Empirical results

3.1. Order of integration

We are testing the series of the MPF equity funds and the selected macroeconomic variables for stationarity, identifying their order of integration and transforming them to stationary series. The results of ADF unit root tests with and without the time trend on both time series and their first differences of the MPF equity fund NAV and selected macroeconomic variables are reported in Table 1. The time lags chosen are based on the Akaike Information Criteria. The results obtained from the third

Table 2
Bivariate cointegration test for the prices of MPF equity funds and macroeconomic variables.

Fund no.	Independent variable			
	HSI	CPI	M2	HIBOR
1	8.7823	23.2532*	7.0808	4.7079
2	7.9053	23.3170*	7.2446	4.6587
3	8.0455	14.4601**	7.2025	9.8953
4	21.9233*	18.9828*	6.5477	6.9608
5	21.8468*	19.0185*	6.5791	7.0101
6	8.9062	14.8624**	6.7761	7.6153
7	21.1104*	16.1678*	6.0612	7.6860
8	8.6922	29.4913*	12.4366	3.9082
9	26.6020*	25.8724*	7.3765	4.3602
10	30.4860*	26.2564*	7.4760	4.5236
11	30.4860*	26.2564*	7.4760	4.5236
12	7.2581	26.8114*	9.3981	4.6362
13	7.2581	26.8114*	9.3981	4.6362
14	7.2581	26.8114*	9.3981	4.6362
15	7.2581	26.8114*	9.3981	4.6362
16	12.2770	24.8595*	10.2651	4.8725
17	12.2770	24.8595*	10.2651	4.8725
18	26.4219*	15.5098*	6.0817	7.2804
19	16.5463*	26.3212*	7.0147	4.9507
20	23.1777*	15.9767*	10.4546	8.9556
21	10.6019	14.4831**	10.2291	8.1507
22	12.8921	27.0391*	8.7752	3.8033
23	6.5317	16.8982*	8.9111	12.3141
24	29.6996*	25.1765*	6.9448	4.8566
25	32.3775*	26.3009*	7.5747	4.6010
26	14.1487**	26.3531*	7.6688	4.2535
27	8.7852	25.2186*	11.4495	4.8153

* Indicates significant at 5%.
** Indicates significant at 10%; the critical values of the ADF tests are developed by McKinnon et al. (1999).

and the fourth column of Table 1 suggest the null hypothesis of the existence of the unit root in time series should not be rejected at 5% level. Therefore all equity funds and macroeconomic variables are not stationary in the time series.

The same test was applied to their first differences and the relative results are summarized in the fifth and the sixth column of Table 1. The results indicate that they are stationary at 5% significance level. Hence, it is concluded that the time series of MPF equity fund NAV and macroeconomic variables are first-ordered integrated i.e. $I(1)$ series, and thus the price levels but not the first differences are subject to cointegration test.

3.2. Cointegration analysis

Since the time series of equity fund NAV and those of selected macroeconomic variables are noted to be $I(1)$, there exists the possibility that they share a long-run equilibrium relationship and thus we proceed to cointegration test. Table 2 presents the results of EG test for bivariate cointegration between the fund NAV and each selected macroeconomic variable. The time lags used in the unit root test for the residuals got from the cointegrating regression are determined similarly based on Akaike Information Criteria. As noted form the table, the NAV of all sample funds are diagnosed to be cointegrated with CPI and 44.44% (12 out of 27) of sample funds have their NAV cointegrated with HSI. The absence of cointegration between the NAV of approximately half of the funds (55.56%) and the stock market index indicates that these funds are trying to construct portfolios which are replicating the composition of constituent stocks in other benchmark indices such as FTSE MPF HK or MSCI HK rather than the conventional Hong Kong stock market index HSI. Chu (2010) find similar results that the Hong Kong equity funds in MPF scheme are trying to replicate different benchmark indices. The

Table 3
Johansen–Juselius multivariate cointegration test dependent variable: equity fund prices independent variables: HSI, CPI, M2, HIBOR.

Fund no.	H_0	Eigenvalue	Trace statistic	$CV_{(trace,\ 5\%)}$
1	$r=0$	0.3028*	85.3987*	69.8188
	$r\le 1$	0.2752*	52.2077*	47.8561
	$r\le 2$	0.1557	22.5966	29.7970
	$r\le 3$	0.0726	7.0179	15.4947
	$r\le 4$	0.0008	0.0740	3.8414
2	$r=0$	0.3014*	85.1870*	69.8188
	$r\le 1$	0.2774*	52.1766*	47.8561
	$r\le 2$	0.1527	22.2771	29.7970
	$r\le 3$	0.0730	7.0225	15.4947
	$r\le 4$	0.0004	0.0390	3.8414
3	$r=0$	0.4287*	69.8040*	69.8188
	$r\le 1$	0.2771*	38.4435	47.8561
	$r\le 2$	0.2291	20.2696	29.7970
	$r\le 3$	0.0804	5.6971	15.4947
	$r\le 4$	0.0177	1.0020	3.8414
4	$r=0$	0.3813*	94.5923*	69.8188
	$r\le 1$	0.2775*	55.2143*	47.8561
	$r\le 2$	0.2314	28.5607	29.7970
	$r\le 3$	0.0815	6.9770	15.4947
	$r\le 4$	0.00004	0.0038	3.8414
5	$r=0$	0.3784*	96.2679*	69.8188
	$r\le 1$	0.2878*	57.2682*	47.8561
	$r\le 2$	0.2362	29.4276	29.7970
	$r\le 3$	0.0851	7.3263	15.4947
	$r\le 4$	0.0003	0.0274	3.8414
6	$r=0$	0.6065*	97.8926*	69.8188
	$r\le 1$	0.4708*	57.7790*	47.8561
	$r\le 2$	0.3677*	30.4109*	29.7970
	$r\le 3$	0.2179	10.6964	15.4947
	$r\le 4$	0.0028	0.1233	3.8414
7	$r=0$	0.4524*	105.2555*	69.8188
	$r\le 1$	0.3638*	59.4823*	47.8561
	$r\le 2$	0.1886	25.1095	29.7970
	$r\le 3$	0.1072	9.2248	15.4947
	$r\le 4$	0.0079	0.6049	3.8414
8	$r=0$	0.3402*	99.1192*	69.8188
	$r\le 1$	0.2713*	55.8651*	47.8561
	$r\le 2$	0.1496	22.9489	29.7970
	$r\le 3$	0.0567	6.0850	15.4947
	$r\le 4$	0.0001	0.0111	3.8414
9	$r=0$	0.3302*	96.9034*	69.8188
	$r\le 1$	0.2663*	55.6091*	47.8561
	$r\le 2$	0.1380	23.7092	29.7970
	$r\le 3$	0.0784	8.4105	15.4947
	$r\le 4$	7×10^{-6}	0.0007	3.8414
10	$r=0$	0.3326*	95.7983*	69.8188
	$r\le 1$	0.2562*	53.7370*	47.8561
	$r\le 2$	0.1298	22.9517	29.7970
	$r\le 3$	0.0782	8.4871	15.4947
	$r\le 4$	0.0001	0.0174	3.8414
11	$r=0$	0.3326*	95.7983*	69.8188
	$r\le 1$	0.2562*	53.7370*	47.8561
	$r\le 2$	0.1298	22.9517	29.7970
	$r\le 3$	0.0782	8.4871	15.4947
	$r\le 4$	0.0001	0.0174	3.8414

Table 3 (*Continued*)

Fund no.	H_0	Eigenvalue	Trace statistic	$CV_{(trace,\ 5\%)}$
12	$r=0$	0.3465*	116.8518*	69.8188
	$r\leq 1$	0.2608*	72.6048*	47.8561
	$r\leq 2$	0.2088*	41.1746*	29.7970
	$r\leq 3$	0.1414*	16.8121*	15.4947
	$r\leq 4$	0.0091	0.9512	3.8414
13	$r=0$	0.3465*	116.8518*	69.8188
	$r\leq 1$	0.2608*	72.6048*	47.8561
	$r\leq 2$	0.2088*	41.1746*	29.7970
	$r\leq 3$	0.1414*	16.8121*	15.4947
	$r\leq 4$	0.0091	0.9512	3.8414
14	$r=0$	0.3465*	116.8518*	69.8188
	$r\leq 1$	0.2608*	72.6048*	47.8561
	$r\leq 2$	0.2088*	41.1746*	29.7970
	$r\leq 3$	0.1414*	16.8121*	15.4947
	$r\leq 4$	0.0091	0.9512	3.8414
15	$r=0$	0.3465*	116.8518*	69.8188
	$r\leq 1$	0.2608*	72.6048*	47.8561
	$r\leq 2$	0.2088*	41.1746*	29.7970
	$r\leq 3$	0.1414*	16.8121*	15.4947
	$r\leq 4$	0.0091	0.9512	3.8414
16	$r=0$	0.2872*	89.2288*	69.8188
	$r\leq 1$	0.2352*	54.0120*	47.8561
	$r\leq 2$	0.1491	26.1227	29.7970
	$r\leq 3$	0.0856	9.3243	15.4947
	$r\leq 4$	0.0001	0.0169	3.8414
17	$r=0$	0.2872*	89.2288*	69.8188
	$r\leq 1$	0.2352*	54.0120*	47.8561
	$r\leq 2$	0.1491	26.1227	29.7970
	$r\leq 3$	0.0856	9.3243	15.4947
	$r\leq 4$	0.0001	0.0169	3.8414
18	$r=0$	0.4605*	98.2688*	69.8188
	$r\leq 1$	0.2926*	50.1232*	47.8561
	$r\leq 2$	0.1898	23.1197	29.7970
	$r\leq 3$	0.0820	6.6944	15.4947
	$r\leq 4$	0.0001	0.0126	3.8414
19	$r=0$	0.3488*	100.3377*	69.8188
	$r\leq 1$	0.2348*	55.7200*	47.8561
	$r\leq 2$	0.1848	27.8815	29.7970
	$r\leq 3$	0.0583	6.6195	15.4947
	$r\leq 4$	0.0035	0.3648	3.8414
20	$r=0$	0.8992*	190.8036*	60.0614
	$r\leq 1$	0.8606*	121.9362*	40.1749
	$r\leq 2$	0.7940*	62.8202*	24.2759
	$r\leq 3$	0.3913*	15.4140*	12.3209
	$r\leq 4$	0.0171	0.5176	4.1299
21	$r=0$	0.9346*	176.1614*	69.8188
	$r\leq 1$	0.7089*	77.9632*	47.8561
	$r\leq 2$	0.4430	33.5269	29.7970
	$r\leq 3$	0.2819	12.4559	15.4947
	$r\leq 4$	0.0146	0.5303	3.8414
22	$r=0$	0.2820*	99.6031*	69.8188
	$r\leq 1$	0.2459*	65.1433*	47.8561
	$r\leq 2$	0.2128*	35.7799*	29.7970
	$r\leq 3$	0.0927	10.8833	15.4947
	$r\leq 4$	0.0072	0.7614	3.8414

Table 3 (*Continued*)

Fund no.	H_0	Eigenvalue	Trace statistic	$CV_{(trace,\ 5\%)}$
23	$r=0$	0.4274*	89.6885*	69.8188
	$r\leq1$	0.3576*	56.2249*	47.8561
	$r\leq2$	0.2963	29.6632	29.7970
	$r\leq3$	0.1209	8.5756	15.4947
	$r\leq4$	0.0139	0.8411	3.8414
24	$r=0$	0.3744*	105.3106*	69.8188
	$r\leq1$	0.2428*	56.5251*	47.8561
	$r\leq2$	0.1673	27.5992	29.7970
	$r\leq3$	0.0776	8.5553	15.4947
	$r\leq4$	0.0014	0.1470	3.8414
25	$r=0$	0.3257*	92.5799*	69.8188
	$r\leq1$	0.2554*	51.5915*	47.8561
	$r\leq2$	0.1130	20.9182	29.7970
	$r\leq3$	0.0776	8.4374	15.4947
	$r\leq4$	0.0003	0.0321	3.8414
26	$r=0$	0.2978*	98.2090*	69.8188
	$r\leq1$	0.2230*	61.4309*	47.8561
	$r\leq2$	0.2042*	35.1842*	29.7970
	$r\leq3$	0.1037	11.4208	15.4947
	$r\leq4$	0.0002	0.0279	3.8414
27	$r=0$	0.2742*	85.9672*	69.8188
	$r\leq1$	0.2234*	53.2765*	47.8561
	$r\leq2$	0.1744	27.4768	29.7970
	$r\leq3$	0.0704	7.9279	15.4947
	$r\leq4$	0.0046	0.4731	3.8414

* Indicates significant at 5%.
The critical values of the ADF tests are developed by McKinnon et al. (1999).

EG test suggests that the remaining two variables M2 and HIBOR, by contrast, are not cointegrated with the fund NAV. The absence of cointegration between the fund NAV and these two macroeconomic variables may be due to the fact that the fund NAV is a linear function of some macroeconomic variables.

The results from bivariate analysis may not be convincing for causality between variables and Lutkepohl (1982) supplements that the bivariate cointegration analysis may be spurious because of the omission of relevant variables. Accordingly, a multivariate cointegration analysis has been performed to diagnose the robustness of the results of bivariate cointegration analysis. JJ procedure is conducted for multivariate cointegration analysis and the results of the trace statistics and eigenvalue are reported in Table 3. The results indicate that the null hypothesis of no cointegration between the variables is rejected for all funds at 5% significance level; thus, there exists a linear combination of the $I(1)$ variables that links them in a stable long-run relationship and the fund NAV are concluded to be cointegrated with the combination of the three macroeconomic variables with the local market index. The presence of cointegration suggests that fund NAV share a long-term equilibrium relation with a set of macroeconomic variables, but not with M2 and HIBOR individually as indicated in Table 2. The results indicated from Table 1 to Table 3 summarize that more specifically, although individually the fund NAV and selected macroeconomic variables are integrated of order one, the linear combination of these five variables are integrated of order zero. The eigenvalue statistics reported in Table 3 drop sharply for the alternative hypothesis of four cointegrating vectors ($r\leq4$) against ($r=4$). It may tell us that our models with four variables are fair representations.

3.3. Causality test

This section builds upon the previous unit root and cointegration tests to assess the interactions between the fund NAV and the macroeconomic variables. For cointegrated cases, ECM specified by

Table 4
Tests of Granger's causality between the prices of MPF equity funds and macroeconomic variables.

Fund no.	Causality		
	HSI dnc[a] prices *F*-statistics	M2 dnc prices *F*-statistics	HIBOR dnc prices *F*-statistics
1	4.2517*	2.5173**	0.4252
2	3.9459*	2.5889**	0.4172
3	1.8200	1.6249	0.1443
4	NA[b]	2.6348**	0.5198
5	NA[b]	2.6717**	0.5321
6	4.2282*	0.8004	0.1829
7	NA[b]	2.1372	1.0047
8	1.8653	5.5842*	0.0508
9	NA[b]	3.4850*	0.0155
10	NA[b]	3.6077*	0.0012
11	NA[b]	3.6077*	0.0012
12	3.3142*	3.6749*	0.0448
13	3.3142*	3.6749*	0.0448
14	3.3142*	3.6749*	0.0448
15	3.3142*	3.6749*	0.0448
16	4.7087*	3.1779*	0.0638
17	4.7087*	3.1779*	0.0638
18	NA[b]	2.3693**	0.6894
19	NA[b]	2.8647**	0.0161
20	NA[b]	0.1982	0.6851
21	0.7881	0.8607	0.3321
22	5.9499*	3.4795*	0.2096
23	1.0211	2.5224**	0.2694
24	NA[b]	3.5017*	0.0501
25	NA[b]	3.6715*	0.0017
26	NA[b]	3.4544*	0.0128
27	0.8750	3.1822*	0.2742

[a] dnc stands for does not Granger cause.
[b] The causality between the prices of these funds and Hang Seng Index will be investigated by error correction model (ECM), which results are summarized in Table 5.
* Indicates significant at 5%.
** Indicates significant at 10% to reject the null hypothesis of no causality.

Eq. (6) will be adopted. For non-cointegrated cases, the error correction term EC_{t-1} is omitted and the specification in Eq. (4) will be employed. The main focus of this study is to evaluate the informational efficiency of fund NAV; the feedback from the fund NAV to the macroeconomic variables of interest and local market index will not be evaluated.

Table 4 reports the results of bivariate Granger's causality test for the non-cointegrated variables or cases. As noted from column 4 of the table, the overnight HIBOR not only is non-cointegrated with fund NAV but also has no predictive power to the movements of equity fund NAV. Column 2 of the table presents the causality test results for the funds in which the movements of their NAV are not cointegrated with the changes in Hang Seng Index; the lagged changes in HSI is found to Granger cause the fund NAV in most cases (10 out of 15). Changes in M2 are also found to Granger cause the movements of most funds (22 out of 27) at conventional significance level although M2 is found not to be cointegrated with fund NAV as indicated in Table 3, which reflects the policy reaction of the Hong Kong Monetary Authority to the fluctuation in fund NAV.

Table 5 presents the estimates of the vector ECM, which has the purpose to test the hypothesis that the lagged changes in HSI and the error correction term do not cause a current change in the fund NAV of the funds in which NAV are found to be cointegrated with HSI; while Table 6 presents the estimates of ECM to evaluate the causal relation between fund NAV and CPI, which is found to be cointegrated with the fund NAV for all funds as indicated in Table 2. The tables show the error correction terms with the *t*-statistics in parentheses, and the sum of the coefficients on the lagged difference with an F-test statistic indicating the significance of the sum of the coefficients. Different ECMs with truncated lag

Table 5
Estimates of error correction model (ECM) for the fund prices on HSI dependent variable: ΔMPF_t.

Fund no.	α_0	γ	VAR(1)		VAR(2)		*F*-statistics
			ΔMPF_{t-1}	ΔHSI_{t-1}	ΔMPF_{t-1}	ΔHSI_{t-1}	
1	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
2	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
3	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
4	0.0014 [0.0857]	2.2527 [4.8150]	−3.5011 [−7.1979]	0.0004 [5.9909]	−2.0400 [−5.1474]	0.0002 [5.0128]	18.6037*
5	0.0016 [0.0955]	2.2662 [4.7867]	−3.5007 [−7.1571]	0.0004 [5.9593]	−2.0421 [−5.1340]	0.0002 [5.0074]	18.4299*
6	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
7	0.0006 [0.0035]	−0.0023 [−2.1930]	−2.9079 [−4.6562]	0.0030 [3.5963]	−1.7136 [−3.5686]	0.0021 [3.4519]	10.5788*
8	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
9	−0.0103 [−0.1124]	−0.0026 [−4.3046]	−3.3097 [−5.9611]	0.0023 [5.0107]	−1.4827 [−3.6408]	0.0011 [3.6497]	14.7728*
10	0.0156 [0.1721]	2.9329 [4.4905]	−3.3290 [−5.9231]	0.0023 [4.9966]	−1.4711 [−3.6238]	0.0011 [3.6186]	15.0672*
11	0.0156 [0.1721]	2.9329 [4.4905]	−3.3290 [−5.9231]	0.0023 [4.9966]	−1.4711 [−3.6238]	0.0011 [3.6186]	15.0672*
12	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
13	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
14	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
15	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
16	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
17	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
18	0.0165 [0.0723]	1.4872 [3.5406]	−1.9678 [−4.4018]	0.0024 [3.2518]	−0.8105 [−2.2632]	0.0011 [2.1755]	10.8711*
19	0.0155 [0.1611]	3.0657 [4.5058]	−3.2388 [−5.1767]	0.0023 [4.3600]	−1.3633 [−2.9912]	0.0010 [2.8543]	14.1518*
20	−0.0145 [−0.0974]	1.9733 [1.9322]	−2.5442 [−2.8584]	0.0009 [2.3284]	−1.6168 [−2.9308]	0.0006 [2.5566]	3.1949*
21	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
22	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
23	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
24	0.0003 [0.0032]	1.8246 [4.1455]	−2.7088 [−6.5590]	0.0023 [5.1514]	−1.3159 [−4.2039]	0.0012 [3.9349]	16.9797*
25	0.0183 [0.2043]	3.1906 [4.7194]	−3.5467 [−6.2122]	0.0025 [5.2951]	−1.5701 [−3.8989]	0.0012 [3.9170]	15.9003*
26	0.0231 [0.1896]	1.3119 [1.9412]	−1.9375 [−3.6305]	0.0014 [2.5468]	−0.9284 [−2.8695]	0.0007 [2.3701]	9.2621*
27	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]

t-Statistics are reported in parentheses; ECM reflects a long-term equilibrium relationship.

[a] The causality between the prices of these funds and Hang Seng Index is investigated by Granger's causality, which results are summarized in Table 4.

* Indicates significant at 5%.

To reject the null hypothesis of no causality.

Table 6
Estimates of error correction model (ECM) for the fund prices on CPI dependent variable: ΔMPF_t.

Fund no.	α_0	γ	VAR(1)		VAR(2)		F-statistics
			ΔMPF_{t-1}	ΔCPI_{t-1}	ΔMPF_{t-1}	ΔCPI_{t-1}	
1	−0.1861 [−0.1190]	−0.1961 [−3.7972]	−0.4477 [−4.0344]	11.6254 [3.5916]	−0.1333 [−1.2600]	9.6735 [3.9327]	12.1004*
2	−0.1856 [−0.1178]	−0.1958 [−3.8045]	−0.4460 [−4.0193]	11.7311 [3.5987]	−0.1335 [−1.2611]	9.7636 [3.9404]	12.0490*
3	−0.0215 [−0.1402]	−0.1015 [−3.0158]	−0.5282 [−3.7419]	0.9840 [3.1847]	−0.1842 [−1.3110]	0.7171 [3.2710]	7.2159*
4	−0.0022 [−0.1211]	−0.1810 [−3.4304]	−0.5149 [−4.3598]	0.1177 [3.0694]	−0.2142 [−1.8944]	0.1004 [3.4488]	11.8485*
5	−0.0022 [−0.1206]	−0.1786 [−3.4210]	−0.5145 [−4.3685]	0.1173 [3.0638]	−0.2126 [−1.8839]	0.1000 [3.4459]	11.7636*
6	−0.0386 [−0.2201]	−0.1466 [−2.7795]	−0.5444 [−3.3362]	0.8646 [2.8215]	−0.2264 [−1.4290]	0.6851 [3.0921]	6.7608*
7	−0.0600 [−0.3045]	−0.0580 [−2.6260]	−0.5882 [−4.9534]	1.1562 [2.8204]	−0.2105 [−1.7513]	0.9901 [3.3198]	9.4798*
8	−0.0022 [−0.0204]	−0.0702 [−2.9753]	−0.5490 [−5.4223]	0.7272 [3.2475]	−0.1686 [−1.6480]	0.5713 [3.4548]	11.1042*
9	−0.0097 [−0.1024]	−0.1231 [−3.3784]	−0.5195 [−5.0638]	0.6940 [3.6086]	−0.1432 [−1.4214]	0.5733 [4.0328]	12.8182*
10	−0.0045 [−0.0483]	−0.1316 [−3.4953]	−0.5195 [−5.0842]	0.7093 [3.7598]	−0.1432 [−1.4288]	0.5757 [4.0930]	13.3193*
11	−0.0045 [−0.0483]	−0.1316 [−3.4953]	−0.5195 [−5.0842]	0.7093 [3.7598]	−0.1432 [−1.4288]	0.5757 [4.0930]	13.3193*
12	−0.0044 [−0.0496]	−0.2797 [−4.4123]	−0.3806 [−3.5720]	0.7475 [4.3701]	−0.0883 [−0.8835]	0.5650 [4.3566]	13.5335*
13	−0.0044 [−0.0496]	−0.2797 [−4.4123]	−0.3806 [−3.5720]	0.7475 [4.3701]	−0.0883 [−0.8835]	0.5650 [4.3566]	13.5335*
14	−0.0044 [−0.0496]	−0.2797 [−4.4123]	−0.3806 [−3.5720]	0.7475 [4.3701]	−0.0883 [−0.8835]	0.5650 [4.3566]	13.5335*
15	−0.0044 [−0.0496]	−0.2797 [−4.4123]	−0.3806 [−3.5720]	0.7475 [4.3701]	−0.0883 [−0.8835]	0.5650 [4.3566]	13.5335*
16	−0.0404 [−0.2185]	−0.1516 [−3.2223]	−0.5907 [−5.8589]	1.3714 [3.7211]	−0.2415 [−2.5195]	1.2333 [4.5472]	16.7612*
17	−0.0404 [−0.2185]	−0.1516 [−3.2223]	−0.5907 [−5.8589]	1.3714 [3.7211]	−0.2415 [−2.5195]	1.2333 [4.5472]	16.7612*
18	−0.0295 [−0.1314]	−0.2173 [−3.5972]	−0.4785 [−3.9360]	1.5061 [3.4085]	−0.1367 [−1.1979]	1.2043 [3.6025]	11.7818*
19	−0.0043 [−0.0447]	−0.2050 [−3.8074]	−0.4570 [−4.3563]	0.7056 [3.6986]	−0.1426 [−1.4311]	0.5863 [4.0771]	13.6009*
20	−0.0066 [−0.0426]	−0.0376 [−1.4730]	−0.4186 [−2.1890]	0.2679 [1.0829]	−0.3810 [−1.9780]	0.3312 [1.8872]	2.4722
21	−0.0549 [−0.2384]	−0.1426 [−2.6315]	−0.4676 [−2.5785]	0.9332 [2.5225]	−0.1113 [−0.6268]	0.7014 [2.5823]	5.0059
22	0.0002 [0.0204]	−0.0279 [−2.0189]	−0.6682 [−6.8271]	0.0768 [2.9371]	−0.2335 [−2.3369]	0.0735 [3.8907]	13.7885*
23	−0.0454 [−0.1771]	−0.0516 [−2.5593]	−0.5984 [−4.4830]	1.5558 [2.8822]	−0.2240 [−1.6715]	1.2555 [3.3189]	7.9727*
24	−0.0097 [−0.0798]	−0.1420 [−3.3688]	−0.5413 [−5.2235]	0.8010 [3.2458]	−0.2048 [−2.0416]	0.6843 [3.6818]	13.7587*
25	−0.0027 [−0.0293]	−0.1318 [−3.5001]	−0.5186 [−5.0877]	0.7065 [3.7698]	−0.1428 [−1.4278]	0.5757 [4.1230]	13.3810*
26	−0.0055 [−0.0482]	−0.1472 [−3.6370]	−0.5153 [−5.0418]	0.9147 [3.9470]	−0.1911 [−1.9137]	0.7058 [4.0756]	12.7702*
27	−0.0081 [−0.0342]	−0.0813 [−2.9263]	−0.5503 [−5.4870]	1.0217 [2.0680]	−0.1794 [−1.8204]	0.9953 [2.6750]	12.6662*

t-Statistics are reported in parentheses; ECM reflects a long-term equilibrium relationship.

* Indicates significant at 5%.

To reject the null hypothesis of no causality.

Table 7
Multivariate error correction model dependent variable: ΔMPF_t.

Fund no.	α	γ	VAR(1) VAR(2)					F-statistics
			ΔMPF_{t-1}	ΔCPI_{t-1}	ΔHSI_{t-1}	ΔM_{t-1}	$\Delta HIBOR_{t-1}$	
1	−0.0608 [−0.0393]	2.3116 [3.5286]	−2.0705 [−2.9857]	4.1187 [1.9236]	0.0143 [1.8506]	0.0001 [4.3825]	−2.1595 [−0.8869]	6.382*
			−1.2432 [−2.2417]	5.5545 [2.5934]	0.0115 [1.7461]	5.19×10^{-5} [2.4776]	−0.1058 [−0.0429]	
2	−0.0587 [−0.0378]	2.2993 [3.5381]	−2.0461 [−2.9634]	4.3337 [2.0041]	0.0141 [1.8237]	0.0001 [4.3946]	−2.2423 [−0.9146]	6.376*
			−1.2277 [−2.2199]	5.7284 [2.6560]	0.0114 [1.7215]	5.29×10^{-5} [2.5002]	−0.1641 [−0.0660]	
3	0.0051 [0.0318]	1.1375 [1.7064]	−1.8906 [−2.8077]	0.4253 [2.0356]	0.0008 [1.7458]	4.76×10^{-6} [2.24819]	−0.1535 [−0.7293]	2.980
			−1.0453 [−2.0107]	0.4398 [2.2249]	0.0005 [1.4640]	1.92×10^{-6} [1.1535]	−0.0713 [−0.3376]	
4	0.0003 [0.0207]	1.9098 [4.3359]	−3.4613 [−6.8226]	0.0539 [2.4548]	0.0003 [5.2514]	1.49×10^{-6} [5.3217]	−0.0048 [−0.2013]	9.834*
			−2.0509 [−4.9796]	0.0565 [2.5376]	0.0002 [4.2093]	8.17×10^{-7} [3.9689]	−0.0041 [−0.1745]	
5	0.0005 [0.0347]	1.9249 [4.3309]	−3.4680 [−6.7960]	0.0522 [2.3911]	0.0003 [5.2421]	1.50×10^{-6} [5.3405]	−0.0066 [−0.2782]	9.778*
			−2.0421 [−4.9393]	0.0545 [2.4570]	0.0002 [4.1809]	8.22×10^{-7} [3.9833]	−0.0057 [−0.2445]	
6	−0.0214 [−0.1344]	2.2926 [3.3721]	−3.6701 [−4.6308]	0.3066 [1.8023]	0.0017 [3.6447]	7.05×10^{-6} [3.9062]	−0.1402 [−0.6064]	5.012*
			−2.2147 [−3.5796]	0.3730 [2.1715]	0.0012 [2.9566]	3.29×10^{-6} [2.2238]	−0.1714 [−0.7431]	
7	−0.0367 [−0.1937]	0.9296 [1.9220]	−2.2496 [−4.3263]	0.6189 [2.2494]	0.0018 [2.9099]	8.0×10^{-6} [2.6087]	−0.1329 [−0.4890]	5.682*
			−1.3827 [−2.9674]	0.7263 [2.8481]	0.0014 [2.4537]	3.43×10^{-6} [1.5364]	−0.0643 [−0.2376]	
8	0.0133 [0.1254]	1.1100 [2.1017]	−1.9091 [−4.1317]	0.3342 [2.3318]	0.0010 [2.6568]	5.28×10^{-6} [2.9076]	−0.1571 [−0.9518]	5.901*
			−1.0136 [−3.0120]	0.3209 [2.2926]	0.0007 [2.4422]	2.00×10^{-6} [1.4766]	0.0121 [0.0753]	
9	−0.0062 [−0.0663]	1.6113 [2.8575]	−2.2087 [−4.1617]	0.2475 [1.9748]	0.0011 [2.8180]	6.27×10^{-6} [3.6962]	−0.1053 [−0.7505]	6.785*
			−0.9709 [−2.2685]	0.3193 [2.6094]	0.0005 [1.7342]	2.85×10^{-6} [2.2568]	−0.0622 [−0.4348]	
10	0.0096 [0.1051]	1.7853 [3.1614]	−2.2666 [−4.2408]	0.2500 [2.0211]	0.0011 [2.8934]	6.61×10^{-6} [4.0042]	−0.1136 [−0.8224]	7.070*
			−0.9219 [−2.1948]	0.3233 [2.6706]	0.0005 [1.6448]	3.12×10^{-6} [2.5060]	−0.0651 [−0.4613]	
11	0.0096 [0.1051]	1.7853 [3.1614]	−2.2666 [−4.2408]	0.2500 [2.0211]	0.0011 [2.8934]	6.61×10^{-6} [4.0042]	−0.1136 [−0.8224]	7.070*
			−0.9219 [−2.1948]	0.3233 [2.6706]	0.0005 [1.6448]	3.12×10^{-6} [2.5060]	−0.0651 [−0.4613]	
12	0.0056 [0.0606]	−4.0497 [−2.5748]	2.8705 [1.8044]	0.3617 [2.6038]	−0.0027 [−2.2892]	6.04×10^{-6} [3.7210]	−0.1571 [−1.0883]	5.551*
			2.0980 [1.6014]	0.4272 [3.2468]	−0.0018 [−1.8306]	2.26×10^{-6} [1.9256]	−0.0397 [−0.2719]	
13	0.0056 [0.0606]	−4.0497 [−2.5748]	2.8705 [1.8044]	0.3617 [2.6038]	−0.0027 [−2.2892]	6.04×10^{-6} [3.7210]	−0.1571 [−1.0883]	5.551*
			2.0980 [1.6014]	0.4272 [3.2468]	−0.0018 [−1.8306]	2.26×10^{-6} [1.9256]	−0.0397 [−0.2719]	
14	0.0056 [0.0606]	−4.0497 [−2.5748]	2.8705 [1.8044]	0.3617 [2.6038]	−0.0027 [−2.2892]	6.04×10^{-6} [3.7210]	−0.1571 [−1.0883]	5.551*
			2.0980 [1.6014]	0.4272 [3.2468]	−0.0018 [−1.8306]	2.26×10^{-6} [1.9256]	−0.0397 [−0.2719]	
15	0.0056 [0.0606]	−4.0497 [−2.5748]	2.8705 [1.8044]	0.3617 [2.6038]	−0.0027 [−2.2892]	6.04×10^{-6} [3.7210]	−0.1571 [−1.0883]	5.551*
			2.0980 [1.6014]	0.4272 [3.2468]	−0.0018 [−1.8306]	2.26×10^{-6} [1.9256]	−0.0397 [−0.2719]	
16	−0.0126 [−0.0665]	0.4583 [1.2386]	−1.2175 [−4.1240]	0.5578 [2.2001]	0.0005 [1.4218]	7.12×10^{-6} [2.0348]	−0.3689 [−1.1862]	7.334*
			−0.8395 [−3.5413]	0.6789 [2.7134]	0.0008 [2.2451]	1.44×10^{-6} [0.5736]	−0.1479 [−0.4996]	
17	−0.0126 [−0.0665]	0.4583 [1.2386]	−1.2175 [−4.1240]	0.5578 [2.2001]	0.0005 [1.4218]	7.12×10^{-6} [2.0348]	−0.3689 [−1.1862]	7.334*
			−0.8395 [−3.5413]	0.6789 [2.7134]	0.0008 [2.2451]	1.44×10^{-6} [0.5736]	−0.1479 [−0.4996]	
18	0.0028 [0.0123]	1.5984 [2.5175]	−2.0539 [−3.3197]	0.6305 [2.0306]	0.0014 [1.9304]	1.65×10^{-5} [3.3486]	0.0473 [0.1196]	5.417*
			−1.0855 [−2.3851]	0.7546 [2.5198]	0.0010 [1.6455]	6.09×10^{-6} [1.9384]	0.1599 [0.4191]	
19	0.0099 [0.1035]	1.3358 [3.6264]	−2.0600 [−3.7594]	0.2465 [1.9130]	0.0009 [2.2387]	9.16×10^{-6} [4.4820]	−0.0909 [−0.6307]	7.201*
			−0.9113 [−2.0476]	0.3499 [2.7472]	0.0004 [1.3511]	3.72×10^{-6} [2.6763]	−0.0017 [−0.0116]	

Table 7 (*Continued*)

Fund no.	α	γ	VAR(1) VAR(2)					F-statistics
			ΔMPF_{t-1}	ΔCPI_{t-1}	ΔHSI_{t-1}	ΔM_{t-1}	$\Delta HIBOR_{t-1}$	
20	−0.0234 [−0.1584]	1.4435 [1.4634]	−2.2327 [−2.7156]	−0.0271 [−0.1518]	0.0007 [1.9770]	4.25×10^{-6} [2.7049]	−0.5204 [−1.6772]	2.060
			−1.0458 [−1.8564]	0.1955 [1.2725]	0.0003 [1.4303]	-4.68×10^{-7} [−0.3199]	−0.3320 [−1.4281]	
21	−0.0296 [−0.1545]	2.8599 [4.2620]	−3.2234 [−2.8924]	0.9702 [3.3817]	0.0015 [2.0416]	1.38×10^{-5} [5.2101]	0.0747 [0.2466]	5.087*
			−1.3319 [−1.2886]	0.8209 [3.5003]	0.0006 [0.9441]	6.06×10^{-6} [2.9707]	−0.1900 [−0.6674]	
22	0.0017 [0.1417]	0.5982 [2.4916]	−1.4165 [−5.5599]	0.0399 [2.5041]	7.21×10^{-5} [2.7477]	5.11×10^{-7} [2.8644]	−0.0229 [−1.2361]	7.755*
			−0.6251 [−2.9252]	0.0534 [3.3895]	4.29×10^{-5} [1.8336]	2.15×10^{-7} [1.4495]	−0.0210 [−1.1318]	
23	−0.0131 [−0.0493]	0.6585 [1.2752]	−1.5372 [−3.0763]	0.6299 [1.8587]	0.0011 [1.6470]	5.56×10^{-6} [1.6865]	−0.3367 [−0.8694]	3.529
			−0.9166 [−2.1719]	0.7603 [2.2950]	0.0009 [1.5596]	1.58×10^{-6} [0.5994]	−0.1657 [−0.4593]	
24	−0.0005 [−0.0045]	1.1038 [3.3375]	−2.2562 [−5.8329]	0.2405 [1.5396]	0.0013 [3.7722]	1.03×10^{-5} [4.5266]	−0.1987 [−1.1755]	8.850*
			−1.0615 [−3.4615]	0.3264 [2.1145]	0.0007 [2.4612]	5.02×10^{-6} [3.1152]	−0.0887 [−0.5188]	
25	0.0118 [0.1297]	1.9172 [3.2133]	−2.4164 [−4.3662]	0.2562 [2.0892]	0.0012 [3.0808]	6.46×10^{-6} [4.0321]	−0.0899 [−0.6569]	7.185*
			−0.9918 [−2.3679]	0.3195 [2.6600]	0.0006 [1.8374]	3.00×10^{-6} [2.4615]	−0.0572 [−0.4113]	
26	0.0140 [0.1200]	0.9763 [1.9553]	−1.7747 [−4.0654]	0.3922 [2.4802]	0.0010 [2.4678]	5.39×10^{-6} [3.0267]	−0.2480 [−1.4136]	5.926*
			−0.9110 [−3.1546]	0.3971 [2.5575]	0.0006 [2.2316]	1.77×10^{-6} [1.2518]	−0.0508 [−0.2921]	
27	−0.0004 [−0.0020]	0.7450 [2.9584]	−1.1912 [−4.0080]	−0.0182 [−0.0571]	0.0004 [1.0371]	2.13×10^{-5} [3.7280]	−0.1776 [−0.5121]	6.820*
			−0.3985 [−1.7131]	0.4382 [1.3751]	0.0001 [0.4623]	7.81×10^{-6} [2.1209]	−0.1430 [−0.4133]	

t Statistics are included in parentheses. ECM reflects a long-term equilibrium relationship.

* Indicates significant at 5% to reject the null hypothesis of no causality.

lengths of $k = 2$ to $k = 10$ are constructed and we could not extend the lag length because of the small sample size. The model with the lowest AIC is the one for $k = 2$. The existence of causal relation may be indicated by the test that the coefficient of lagged variables and the error term are not jointly zero.

These two estimates reinforce the findings of cointegration between fund NAV and HSI and CPI respectively. In Table 5, the estimates indicate that ΔHSI have significant explanatory power for current ΔMPF movement at either 5% or 10% significance level and the error correction term is significant, showing explicit information on the short-term dynamic interactions among those variables, and suggesting respective feedback effects between the fund NAV and each macroeconomic variable and unidirectional causality running from each variable to the fund NAV. And the F-statistics indicate the null hypothesis that the coefficients of lagged variables and the error term are jointly zero should be rejected at 5% significance level. Table 6 also indicates similar results for CPI.

In general, these findings suggest that two out of three macroeconomic variables and Hang Seng Index are significant in predicting changes in fund NAV. Thus, it can be claimed that fund price variability is fundamentally linked to the macroeconomic variables of interest although the change in fund NAV lags behind the economic situations.

To assess the informational efficiency of the fund NAV in multivariate forms, a fund price equation using ECM is estimated for the macroeconomic variables of interest. As with the bivariate causality analysis, different ECMs with different lag lengths of $k = 2$ to $k = 10$ were constructed and that of $k = 2$ has the lowest AIC, followed by the one for $k = 3$. The models of $k = 6$ to $k = 10$ are completely rejected. Since the multivariate analysis is regarded as a robustness check of our previous bivariate analysis, only the fund price equation is constructed. The estimates of the equation are summarized in Table 7.

The results obtained in the multivariate causality analysis strengthen our previous findings from bivariate analyses. As noted from the table, the estimates suggest temporal causality from macroeconomic variables to the fund NAV in the long run. Consistent with the bivariate causality analysis, the changes in fund NAV are found to be Granger caused by the changes in CPI, HSI and M2, as indicated by significant t-statistics for the individual regression coefficient. The multivariate analysis indicates that HIBOR may not Granger cause the fund NAV, indicated by insignificant t-statistics. The causal link from M2, HSI and CPI to the fund NAV may reflect the importance of the changes in these three variables on the fund NAV movements and the MPF scheme participants should pay more attention on their movements rather than the movements of HIBOR when deciding to increase or decrease the weight of their investments of Hong Kong equity funds in their portfolios. Regarding the signs of the regression coefficients of the estimated models, we may find that the fund NAV are mostly positively related to M2 and the stock market index, but negatively related to the short-term interest rates, which are consistent with the findings of most studies on the relations among fund prices and these variables. The multivariate ECM indicates the fund NAV are positively related to the CPI, such finding is consistent with most of the studies on the relation between the inflation and stock prices in Asian markets.

4. Conclusion

This paper is the first to examine the cointegration and causality relationship among the NAV of Hong Kong equity funds under the Hong Kong MPF scheme, the local stock market index – HSI, and selected Hong Kong macroeconomic variables including the inflation rate proxied by CPI, money supply (M2), and short-term interest rate proxied by overnight HIBOR, during the period 2001–2009. ADF unit root test is first employed to test for stationarity of price levels and first difference of funds' NAV levels, and those of the macroeconomic variables. The results indicate that all of the fund NAV and the economic variables are first order integrated, i.e. their first differences are stationary. Cointegration and causality tests are then performed on the price levels rather than the first differences.

The results from bivariate cointegration test suggest that the fund NAV respond to deviations from the long-run equilibrium path traced between the HSI and CPI; however, the fund NAV are not cointegrated with the other two economic variables money supply M2 and HIBOR. VAR model and error correction model are constructed for cointegrated series and non-cointegrated series respectively to test the causal relationship between the fund NAV and the macroeconomic variables. There seems that the HSI, CPI and M2 have causal relationship with the fund NAV; the short-term interest rate has no causal link with the fund NAV. The local media always pay attention to the effect of changes in short-term interest rate on the movement of stock prices. However, the empirical analysis suggests that the scheme participants may ignore such changes. Even though the fund NAV and those macroeconomic variables may simultaneously affect each other, in general, the fund NAV should not be a leading indicator for macroeconomic variables. That is why this study tests the existence of unidirectional causal relation only.

Extending the analysis to multivariate setting illustrates that fund NAV are cointegrated with the set of macroeconomic variables and suggests direct long-run and equilibrium relations with those variables. The multivariate causal analysis provides further evidence that HIBOR does not have any causal relationship with the fund NAV, indicated by insignificant coefficient of $\Delta \text{HIBOR}_{t-1}$ in ECM. The signs of the coefficients of the macroeconomic variables on fund NAV in ECM are generally consistent with the hypothesized relations. It is interesting to note that the fund NAV are positively related to inflation. We may conclude that inclusion of equity funds in MPF scheme which major purpose is for retirement is a perverse inflation hedges strategy. Further, the ECM exhibits a good forecasting ability.

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