THE EXPECTATIONS HYPOTHESIS OF THE TERM STRUCTURE IN EMERGING FINANCIAL MARKETS: SOME EVIDENCE FROM MALAYSIA (1999-2015)

1. Introduction and motivation

The Expectations Hypothesis of the Term Structure (EHTS) of interest rates states that the return on a long-term financial asset is an average of current and expected short-term interest rates on this asset over the corresponding maturity. This equilibrium relationship relies on an arbitrage condition assuming homogeneity of financial assets in all respects except in the term to maturity, rational expectations of agents, and the absence of relevant transaction costs or taxes. While earlier versions of this theoretical framework relied on risk neutrality (the so called "Pure Expectations" theory), subsequent extensions introduced a risk-premium component as a further factor affecting long-term interest rates (the so called "Liquidity Premium" theory).

The EHTS has relevant implications involving both finance and economics. In the former case, this relationship is important for pricing different varieties of financial instruments; in the latter case, a large body of empirical literature documents the good predictive power of the EHTS for many economic variables including short-term interest rates (Fama and Bliss, 1987), inflation (Mishkin, 1990; Caporale and Pittis, 1998), and real economic activity (Estrella and Hardouvelis, 1991; Venetis *et al*., 2003). At the macroeconomic level, moreover, the EHTS is relevant to understand the impact of monetary policy and its transmission mechanism. The modern approach to monetary policy implementation assumes in fact that the Central Bank controls a short-term policy rate and that monetary impulses are conveyed to the real economy by means of equilibrium adjustments operating through the yield curve (Bernanke and Blinder, 1992; Clarida *et al*., 1999).

Give its far-reaching implications, the EHTS has been subject to intensive empirical testing.

As regards industrialized countries, earlier contributions support the existence of an equilibrium relationship in the term structure of

US interest rates (Hall *et al.*, 1992; Engsted and Tanggaard, 1994), although parameters restrictions associated with the stricter version of the EHTS are usually rejected (see, among others, Drakos, 2001 for Greece; Masih and Ryan, 2005 for Australia, and Esteve *et al.*, 2013 for Spain).

Quite interestingly, similar results hold for many emerging market economies, where applied research received a major impetus from the liberalization of financial markets implemented during the last decades. Overall, cointegration among interest rates at different maturities is still a pervasive empirical regularity, although the "Pure" version of the EHTS is usually rejected (see, among others, Cooray, 2003 for Sri Lanka; Yoo and Oh, 2005 for Korea; Tabak, 2009 for Brazil; Buigut and Rao, 2010 for Hong Kong, and Tronzano 2015a and 2015b for India).

This paper contributes to the literature focusing on Malaysia during the period subsequent to the financial crisis experienced by East-Asian economies in 1997-98.

The motivation behind the present research is twofold:

1. Malaysia represents an interesting case-study, both for its economic role among the group of the so called ASEAN-4 countries, and for its long-lasting experience of financial liberalization starting since the first half of the 1970s;
2. Applied research on this country is surprisingly scant, with only few papers addressing the validity of the EHTS both before and after the Asian financial crisis.

As regards the former point, Malaysia is a very dynamic economy inside the group of ASEAN countries, as witnessed by its strong macroeconomic fundamentals in the years immediately preceding the outbreak of the Asian financial crisis. Since the beginning of the 1990's this country experienced a rapid GDP growth, stable inflation, falling unemployment, and almost persistent fiscal surpluses (Goh *et al.*, 2003, Appendix B). Similarly to other outstanding Asian economies (such as India), Malaysia implemented a gradual approach in its financial liberalization programs, although the interest rates deregulation phase was initiated much earlier (Ang and Sen, 2011). An initial step towards financial markets liberalization was taken in 1971, introducing market-determined interest rates for longer term deposits, while in 1978 Malaysia's Central Bank allowed commercial banks to freely determine deposit and lending rates. These measures were complemented with a progressive deregulation of exchange rate controls in the 1970's and in the 1980's, and a capital market reform in the following decade removing barriers between different types of financial institutions.

Turning to the latter point, applied literature testing the EHTS has largely neglected Malaysia's experience. To the best of my knowledge, only two papers have addressed this issue. Ghazali and Low (2002) focuses on Malaysia's experience during the pre-crisis period. Although documenting the existence of cointegration, these authors do not analyze parameters estimates of the long-run equilibrium relationship. This research is therefore silent about the validity of alternative versions of the EHTS. Elshareif and Tan (2010) implements more powerful cointegration techniques, but is again uninformative about the existence of potential risk premia components. Moreover, the limited number of observations relative to the post-crisis phase precludes to reach robust evidence about the EHTS during this period.

This paper contributes to the empirical literature focusing on Malaysia's experience after the 1997-1998 Asian financial crisis and exploring the term structure of interest rates in a multivariate cointegration framework.

I improve the available evidence in two main respects: (a) testing some parameters restrictions on cointegrating vectors and thus exploring the existence of potential risk premia components at various maturities; (b) performing causality tests between short and long-term interest rates and thus re-assessing some controversial evidence documented in previous research.

The outline of the paper is as follows. The next section motivates the selection of the sample period and performs a preliminary data analysis. Section 3 implements cointegration tests in a multivariate framework and explores causality among interest rates in a vector error correction framework. Section 4 complements causality tests through a forecast error variance decomposition analysis, and provides further evidence on term structure dynamics. Section 5 concludes.

2. Sample selection, data set and preliminary data analysis

The Asian financial crisis started in July 1997 had serious contagion effects on the Malaysian term structure of interest rates which reached an all-time peak between the end of 1997 and the first months of 1998. In September 1998, the government introduced a series of capital control measures including a fix peg for the Malaysian Ringgit (MR) to the US dollar (at a rate of 3.80 MR to one US dollar), restrictions on the outflow of portfolio investments, and the lifting of offshore trading for the domestic currency. The strong instability of this period is well captured by a temporary peak of the Malaysian financial repression index (see Ang and McKibbin, 2007, Fig. 1, p. 222) and the downgrading of Malaysia's sovereign debt ratings by international credit rating agencies. Capital controls were then progressively relaxed from February 1999 to September 1999 in the presence of increasing economic stability (Abbas and Espinoza, 2006).

Since the drastic policy actions described above mark a temporary suspension of the financial liberalization process, I select August 1999 as the starting point for the empirical investigation.

This paper relies therefore on monthly data ranging from 1999.8 to 2015.2. More specifically, I use data on government bond yields for maturities of one, two, three and four years[1]. This data sample allows a useful comparison with earlier results for the Malaysian term structure relative to the pre-crisis period, where a very similar set of nominal yields is employed (see Ghazali and Low, 2002, section 4).

As a prerequisite for cointegration analysis, interest rates series were submitted to standard unit root tests, namely the KPSS test (Kwiatkowski *et al.*, 1992) and the DF-GLS test (Elliot *et al.*, 1996)[2]. Overall, these testing procedures provide substantial evidence that Malaysian yield series are integrated of order one (I(1))[3].

Figure 1 plots nominal interest rates data over the selected sample period.

Rather strong comovements in asset returns are apparent from this figure, particularly in the central part of the sample, thus providing some informal evidence for the existence of cointegration

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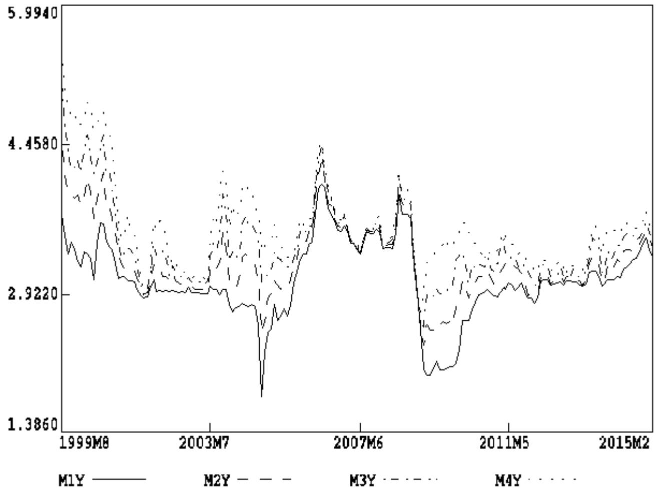
[1] Nominal interest rates are obtained from Thomson Reuters – Datastream, and are expressed in percentage per annum. The codes for these series are the following: "MYGBOND1Y" (1-year maturity); "MYGBOND2Y" (2-year maturity); "MYGBOND3Y" (3-year maturity); "MYGBOND4Y" (4-year maturity).

[2] Details about the results from these tests are available from the author upon request.

[3] The results for the 1-year maturity are slightly less clear-cut, since both KPSS and DF-GLS support level stationarity while rejecting trend stationarity at conventional significance levels. However, since one relevant topic addressed in this research is the direction of causality along the term structure, the 1-year government bond yield has been included in the empirical investigation.

and in support of the EHTS. Focusing on the initial and the last part of the sample, comovements between asset returns at longer maturities are still quite substantial, whereas the 1-year interest rate exhibits a more distinct pattern.

FIGURE 1 - *Malaysia: Government Bond Yields at Various Maturities*



The estimated correlation matrix of variables corroborates this visual evidence. Correlation coefficients between yields at longer maturities display notably high values (inside a range of 0.82-0.94), whereas those between the 1-year interest rate and the remaining rates are lower (inside a range of 0.50-0.89).

3. Empirical Evidence

3.1 Cointegration Tests and Parameters Restrictions on Cointegrating Vectors

Let $i_t^{(n)}$, $i_t^{(m)}$ denote, respectively, the long term and the short term interest rates (m < n). Assuming the existence of a (constant) risk premium component (θ_{nm}) that may vary with the maturity of rates, the EHTS may formally be expressed as:

$$i_t^{(n)} = 1/k \sum_{i=0}^{n} E_t \left(i^{(m)}_{t+i}\right) + \theta_{nm} \qquad (1)$$

where $k = n/m$ is an integer and E_t is the expectations operator.

A large bulk of applied literature relies on tests obtained reparametrizing equation (1) inside the following linear regression framework:

$$i_t^{(n)} = \alpha + \beta\ i_t^{(m)} + \varepsilon_t \tag{2}$$

where $i_t^{(n)}$, $i_t^{(m)}$ are the long and short rates defined above, α and β are parameters, and ε_t are the regression residuals.

The EHTS implies that nominal returns are linked through a long-run equilibrium relationship. Since nominal interest rates are typically I(1) variables, the validity of the EHTS is usually assessed testing for the existence of cointegration between $i_t^{(n)}$ and $i_t^{(m)}$ with a cointegrating vector (1, -1) (e.g. Campbell and Shiller, 1987; Taylor, 1992). This restriction is commonly known as the "symmetry " or "zero-sum" restriction, and expresses the existence of a one-to-one long-run relationship between interest rates at different maturities. Additionally, testing the further restriction $\alpha = 0$ in equation (2), allows to disentangle between the "Pure" version of the EHTS ($\alpha = 0$) and the "Liquidity Premium" version ($\alpha > 0$) positing a significant risk premium component at all temporal horizons.

This discussion can be generalized from the bivariate case outlined in equation (2) to a system of (N) nominal interest rates. In this case, the EHTS predicts that each yield series is cointegrated with the short term yield $i_t^{(m)}$. Therefore, in a system of N yields, the (N-1) spread vectors belonging to the set [(-1, 1, 0, ..., 0) , (-1, 0, 1, ..., 0), ..., (-1, 0, 0, ..., 1)'] are linearly independent and underlie a cointegration space of rank (N - 1) (Hall *et al*., 1992).

Testing the EHTS in a multivariate cointegration framework exploits one basic implication of this theory, namely that a system of (N) non-stationary yields should have one common stochastic trend driving interest rates. This approach delivers more robust inferences than the applied literature relying on a bivariate framework, since term structure innovations jointly affect the whole spectrum of interest rates maturities (see, among others, Hall *et al*., 1992; Engsted and Tanggaard, 1994; Konstantinou, 2004; Masih and Ryan, 2005).

Drawing on the above discussion, this section implements a multivariate cointegration analysis on the four-dimensional system of government bond yields described in section 2. More specifically, I first assess if the rank of the cointegration space is consistent with the main predictions of the EHTS, and then test some key parameters restrictions on the cointegrating vectors in order to investigate the existence of significant risk premium components.

The analysis relies on the standard Full Information Maximum

Likelihood approach proposed in Johansen (1995). Although alternative methodologies are available to determine the number of common trends, this approach provides the most straightforward way to test the hypotheses on the cointegrating vectors (see Engsted and Tanggaard, 1994, section 2, for a more complete discussion).

Figure 1 points out that Malaysian government bond yields are not trended along the sample period. The cointegrating VAR is therefore estimated imposing the usual restriction on the constant term, implying the absence of a linear deterministic trend. The optimal VAR order (p) is selected through standard model selection criteria (AIC, SBC), and on this basis I set p = 2. Diagnostic checks on the estimated equations reveal that this lag length allows to exclude residuals serial correlation in all cases.

Table 1 reports the results from cointegration tests on the Malaysian term structure.

Table 1 - *Malaysian Government Bond Yields*
(Monthly Data: 1999.8 – 2015.2; 187 observations)

Cointegration Tests in a 4-Dimensional System

Null	Alternative	λ_{max}
$r = 0$	$r = 1$	63.69**
$r \leq 1$	$r = 2$	44.63**
$r \leq 2$	$r = 3$	13.68
$r \leq 3$	$r = 4$	5.78

Null	Alternative	λ_{trace}
$r = 0$	$r \geq 1$	127.79**
$r \leq 1$	$r \geq 2$	64.10**
$r \leq 2$	$r \geq 3$	19.46*
$r \leq 3$	$r = 4$	5.78

λ max and λ trace are the two statistics for the test of the cointegration rank.
The data vector includes nominal interest rates on government bonds at 4-year, 3-year, 2-year, and 1-year maturities.
Cointegration with restricted intercepts and no trends in the VAR. Optimal lag length: p = 2.
** indicates significance at the 5% level. * indicates significance at the 10% level.
The 95% critical values for λ max are: $r = 0$, 28.27; $r \leq 1$, 22.04; $r \leq 2$, 15.87; $r \leq 3$, 9.16. The 90% critical values for λ max are: $r = 0$, 25.8; $r \leq 1$, 19.86; $r \leq 2$, 13.81; $r \leq 3$, 7.53.
The 95% critical values for λ trace are: $r = 0$, 53.48; $r \leq 1$, 34.87; $r \leq 2$, 20.18; $r \leq 3$, 9.16. The 90% critical values for λ trace are: $r = 0$, 49.95; $r \leq 1$, 31.93; $r \leq 2$, 17.88; $r \leq 3$, 7.53.

The upper section reports the results of the Maximal Eigenvalue test (λ_{max}), while those relative to the Trace test (λ_{trace}) appear in the lower section.

The null hypotheses that there are at most zero or one cointegrating vectors are consistently rejected by both Likelihood Ratio (LR) statistics at standard significance levels. As regards the null hypothesis that there are at most two cointegrating vectors, the value of λ_{max} is marginally lower than the 10% critical value, whereas λ_{trace} rejects this null at a 10% level.

Although these last results are slightly more uncertain, the existence of three cointegrating vectors is definitely more plausible for two reasons.

First, from a purely technical perspective, there is a large consensus in the literature about the better performance of λ_{trace} with respect to the other LR test statistic. The Monte Carlo evidence reported in Toda (1994), comparing the small sample performance of these tests, reveals that λ_{trace} performs better in some situations where the power is low. Lütkepol *et al.* (2000) reiterate this conclusion, considering a wider set of data generation processes and higher dimensional systems. On the basis of their simulation exercise, these authors recommend the use of λ_{trace} (which in the context of the present research leads to select three cointegrating vectors).

Beyond these technical aspects, the existence of three cointegrating vectors is supported by further evidence from the Malaysian term structure. In some additional tests inside a bivariate framework, I detect three significant cointegrating vectors between the short term (1-year) interest rate and nominal yields at longer maturities (respectively, 2-year, 3-year, and 4-year)[4].

To sum up, the evidence reported in Table 1, complemented by further results on the long-run properties of nominal interest rates, suggests that the Malaysian term structure is driven by one common stochastic trend. This term structure displays therefore a cointegration property that prevents nominal yields from drifting too far apart from equilibrium, thus eliminating the occurrence of persistent profitable opportunities. This finding supports one basic testable implication of the EHTS.

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[4] The evidence for these interest rates pairs is obtained through the standard Engle and Granger (1987) approach for cointegration testing in a bivariate framework. In all cases, the null hypothesis of non-stationarity of regression residuals is rejected at a 5% confidence level. These results are available upon request.

Having established that the rank of the cointegration space is three, I now assess two important restrictions on the parameters of cointegrating vectors.

The former is the so called "zero-sum" or "symmetry" restriction, associated with the stationarity of interest rates spreads, which in the simple bivariate case outlined at the beginning of this section, corresponds to testing that $\beta = 1$ in equation (2). The latter is the joint restriction of "symmetry" and "zero risk premia" (i.e. $\alpha = 0$ and $\beta = 1$ in equation (2)) which characterizes the "Pure" version of the EHTS as opposed to its "Liquidity Premium" specification.

In line with the multivariate cointegration approach followed in this section, these restrictions are explored inside the 4-dimensional system of Malaysian interest rates outlined in section 2. Drawing on previous cointegration tests, I assume the existence of three cointegrating vectors and identify three long-run equilibrium relationships including the 1-year yield ($i^{(1)}$) and other yields at longer maturities (i.e., respectively, $i^{(2)}$, $i^{(3)}$, and $i^{(4)}$). This provides a system of three equilibrium relationships among different interest rates pairs. I then impose some over-identifying restrictions in order to explore the validity of the "symmetry" restriction and of alternative theoretical specifications of the EHTS.

Table 2 reports the results from LR tests about the restrictions on cointegrating vectors.

Focusing on the upper section of this table, the LR test does not reject the "zero-sum" restriction at a 1% significance level. Note, however, that the reported value for the LR statistic is quite high, thus leading to reject the joint unbiasedness assumption for the three cointegrating vectors if one assumes a slightly less restrictive significance level of 5%.

These uncertain results for the "symmetry" restriction reflect mainly the fact that the estimates of the slope coefficient (β) in the identified cointegrating equations are rather imprecise, particularly at the longer end of the Malaysian term structure.

Actually, although significant long-run equilibrium relationships exist between the 1-year yield and nominal interest rates at longer maturities, there are some episodes during which co-movements between the 1-year rate and other nominal yields are not so close as the EHTS would predict. This is particularly evident during the second half of 2004, when the 1-year rate exhibits a reduced volatility before reaching an all-time low in November 2004; an analogous pattern is apparent during the first quarter of 2009, when the 1-year

Table 2 - *Malaysian Term Structure*

EHTS Restrictions: (a) Symmetry

	Vector 1	Vector 2	Vector 3
$i^{(1)}$	1.000	1.000	1.000
$i^{(2)}$	-1.000	-0.000	0.000
$i^{(3)}$	0.000	-1.000	0.000
$i^{(4)}$	0.000	-0.000	-1.000
θ_{ls}	0.1750 (0.0670)	0.3234 (0.1137)	0.4889 (0.1666)
Likelihood Ratio Test of Symmetry Restrictions: 10.31** [0.016]			

EHTS Restrictions: (b) Symmetry + Zero Risk Premia

	Vector 1	Vector 2	Vector 3
$i^{(1)}$	1.000	1.000	1.000
$i^{(2)}$	-1.000	-0.000	0.000
$i^{(3)}$	-0.000	-1.000	0.000
$i^{(4)}$	0.000	-0.000	-1.000
θ_{ls}	-0.000	0.000	-0.000
Likelihood Ratio Test of Symmetry and Zero Risk Premia: 17.649*** [0.007]			

Cointegration with restricted intercepts and no trends in the VAR.
Conditional standard errors in parentheses below parameters estimates.
The Likelihood Ratio test for the symmetry restriction (a) is distributed as a χ^2 with three degrees of freedom.
The Likelihood Ratio test for the joint restriction (b) is distributed as a χ^2 with six degrees of freedom.
p values in square brackets behind Likelihood Ratio test statistics.

rate experiences again a large drop whereas the term structure at longer maturities displays milder reactions (see Figure 1).

Thus, differently from other emerging market economies where the "symmetry" restriction is more strongly supported, both in a multivariate set up (e.g. Tronzano, 2015b for India) and on a bilateral basis (e.g. Tabak, 2009 for Brazil), the overall evidence for Malaysia appears more uncertain in this regard.

Since θ_{nm} is treated as a free parameter when testing the "symmetry" restriction, the estimated values of this coefficient in the upper section of Table 2 provide a quantitative assessment about the relevance of risk premium components at various spread maturities[5].

As shown in this table, the values of θ_{nm} rise monotonically as the spread between the 1-year yield and the remaining interest rates gets larger. More specifically, the estimated value of θ_{nm} is 0.175 for the shortest interest rate pair ($i^{(1)}$, $i^{(2)}$), while reaching a value of 0.488 for the longest time horizon ($i^{(1)}$, $i^{(4)}$). Moreover, all estimates of θ_{nm} are statistically significant.

This evidence strongly supports the "Liquidity Preference Hypothesis" (Hicks, 1946), according to which investors require a risk premium in order to compensate for the greater risk associated with an investment on longer time periods.

The existence of significant risk premium components runs against the validity of the "Pure" version of the EHTS: to the best of my knowledge, no previous research on Malaysia provides clear evidence in this direction.

The lower section of Table 2 tests the joint restriction of "symmetry" and "zero risk premia". The LR statistics for this joint restriction at a multivariate level strongly rejects the null hypotheses of equi-proportional interest rates movements and of absence of risk premia. In the light of the previous discussion, this rejection is most likely due to the existence of significant risk premium components in all cointegrating vectors. This additional result provides further robust evidence against the validity of the "Pure" version of the EHTS.

To sum up, the analysis of this section leads substantial support to the EHTS for Malaysia in the period following the 1997-1998 Asian financial crisis, although some important qualifications are in order as regards joint tests about parameters restrictions on cointegrating vectors.

Multivariate cointegration tests point out the existence of one common stochastic trend, while this result is corroborated by additional cointegration tests in a bivariate framework. This evidence is highly supportive of the EHTS, and is in line with previous

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[5] The θ_{nm} parameter defined in equation (1) corresponds to the constant (α) parameter in the re-parametrization of this equation in a linear regression framework (see equation (2)).

results for Malaysia relative to the pre-crisis period (Ghazali and Low, 2002).

The zero-sum restrictions on cointegrated vectors are not rejected at a 1% confidence level, but this result is reversed at less restrictive significance levels. Therefore this analysis does not deliver univocal evidence about the existence of one-to-one comovements of nominal yields at different maturities. The policy implications of this result will be discussed in the next section, after implementing some causality tests on the Malaysian term structure.

The evaluation of parameters restrictions on cointegrated vectors, finally, reveals the existence of significant risk premium components at all temporal horizons, whose quantitative relevance increases with spreads maturities in line with the predictions of the "Liquidity Premium" theory.

3.2 Causality Tests on the Malaysian Term Structure of Interest Rates

The validity of the EHTS is of paramount importance to evaluate the effectiveness of the transmission mechanism of monetary policy.

The modern approach to monetary policy implementation assumes that the Central Bank sets a short-term policy rate on the basis of a social welfare function incorporating inflation and (possibly) an output target (Clarida *et al.*, 1999). The transmission of monetary policy impulses is then viewed as running from the short-term policy rate to longer term interest rates through the no arbitrage equilibrium condition underlying the EHTS. This equilibrium condition is therefore crucial to ensure that monetary impulses are transmitted to longer term rates, affecting the interest sensitive components of aggregate demand and, finally, output and employment.

In order for the above transmission mechanism to work properly, the direction of causality between nominal yields across the term structure must obviously run from the short term policy rate to longer term interest rates and not the other way round. If this is not the case, the short-term policy instrument is no more exogenous, and the ultimate effects of monetary policy are made more uncertain by complicated feedbacks in the nominal interest rates structure.

Engle and Granger (1987) show that, if two variables are cointegrated, there always exists a causal relationship between them at least in one direction. More specifically, a system of cointegrated variables always admits a corresponding error correction representation, where some variables react to the level of disequilibrium in the cointegrating relationship.

The analysis of the previous section documents the existence of three cointegrating vectors between the shorter term yield (1-year) and other interest rates at longer maturities (respectively 2-year, 3-year, and 4-year).

Drawing on these results, the present section implements a Vector Error Correction approach in order to explore the causal relationships inside the Malaysian term structure, and assess if the underlying macroeconomic conditions are appropriate for a monetary policy strategy based on a short-term interest rate target.

This topic deserves a particular attention in the light of some controversial results obtained in previous research on Malaysia. Ghazali and Low (2002) analyze the period 1984-1999 using monthly data on government securities. These authors find significant long-run causal relationships from long to short-term interest rates, although documenting some short-run causality in the reverse direction. Focusing on the more recent period, Elshareif and Tan (2010) do not confirm the major role of longer term interest rates as equilibrium attractors, and conclude that the Malaysian monetary authority can effectively target the short-term interest rates to monitor the long-term rate and macroeconomic fundamentals.

The present section relies on bilateral Vector Error Correction Models (VECMs) assuming the 1-year rate as a proxy for the short-term policy rate ($i^{(m)}_t$). The dynamic linkages in the Malaysian term structure are thus explored extending the spectrum of longer term maturities from 2 to 4 years focusing on the following interest rates pairs: (i_1, i_2), (i_1, i_3), (i_1, i_4).

Given the existence of cointegration, a bivariate VECM for these variables may be specified as follows:

$$\Delta\, i^{(m)}_t = \delta_1 + \gamma_1 RES_{t-1} + \text{lagged}(\Delta i^{(m)}_t\,,\, (\Delta i^{(n)}_t\,) + \varepsilon_{1t} \tag{3}$$

$$\Delta\, i^{(n)}_t = \delta_2 + \gamma_2 RES_{t-1} + \text{lagged}(\Delta i^{(m)}_t\,,\, (\Delta i^{(n)}_t\,) + \varepsilon_{2t} \tag{4}$$

where $\Delta\, i^{(m)}_t$ represents changes in the short-term interest rate (m = 1); $\Delta\, i^{(n)}_t$ represents changes in long-term interest rates (n = 2, 3, 4); RES_{t-1} is the lagged error correction term from the cointegrating equation; δ_1 and δ_2 are parameters; γ_1 and γ_2 are the speed of adjustments coefficients; ε_{1t} , ε_{2t} are white-noise residuals.

A major advantage of the VECM specification is that it allows to disentangle between different sources of causality related to long and short-run dynamics.

The error correction parameters (γ_1, γ_2) provide information about the adjustment process towards the long-run equilibrium, and therefore the direction of long-run causality. A negative and significant error correction parameter implies that the left-hand variable in the corresponding equation of the VECM adjusts to eliminate deviations from long-run equilibrium. This analysis is usually defined as a test of weak exogeneity in the literature (Engle *et al.*, 1983; Engle and Granger, 1987).

The evidence about short-run causality can instead be obtained by testing the joint significance of lagged coefficients in each VECM equation, in line with the standard approach outlined in Granger-Sims causality tests[6].

A joint test for the null hypotheses that an error correction parameter is equal to zero and lagged parameters are equal to zero provides, finally, a test for strong exogeneity of the left-hand variable in the corresponding equation of the VECM.

The VECM summarized in equations (3)-(4) was estimated for the three interest rates pairs mentioned above. The optimal VECM order was selected through standard AIC/SBC information criteria and Likelihood Ratio tests of (p) versus (p+1) lags specifications. In all cases, the above procedures led to select p = 1 as optimal lag order. Diagnostic tests on all individual equations pointed out that a VECM (1) specification removes residuals serial correlation.

Table 3 summarizes the main evidence from VECM models for short and long-term interest rates, in terms of error correction parameters estimates, LR tests for short-run causality, and Wald statistics for strong exogeneity.

The error correction parameter in the equation normalized on the short rate (γ_1) is never statistically significant. Conversely, the error correction parameter relative to the longer term interest rate (γ_2) is negatively signed and strongly significant for all interest rates pairs. These results document that, along the whole range of the maturity structure, only long-term interest rates adjust to correct temporary deviations from equilibrium: this provides robust evidence of long-run unidirectional causality from short to long-term rates.

[6] In the present paper, in the equation normalized on $\Delta\ i^{(m)}_t$ (eq. (3)), one tests the joint significance of lagged coefficients relative to $\Delta\ i^{(n)}_t$. Similarly, in the equation normalized on $\Delta i^{(n)}_t$ (eq. (4)), one tests the joint significance of lagged coefficients relative to $\Delta\ i^{(m)}_t$.

TABLE 3 - *Malaysian Term Structure*

Vector Error Correction Models for Short and Long Nominal Interest Rates

	(i_1, i_2)	(i_1, i_3)	(i_1, i_4)
γ_1	-0.028 (-0.54)	-0.021 (-0.66)	-0.017 (-0.75)
γ_2	-0.173*** (-3.25)	-0.145*** (-3.93)	-0.097*** (-3.68)
Null Hp: Lagged values of $\Delta\, i^{(n)}_t = 0$ in equation normalized on $\Delta\, i^{(m)}_t$	2.43 [0.119]	1.623 [0.203]	1.520 [0.218]
Null Hp: Lagged values of $\Delta\, i^{(m)}_t = 0$ in equation normalized on $\Delta\, i^{(n)}_t$	0.430 [0.512]	0.680 [0.410]	0.149 [0.699]
Strong exogeneity for $(\Delta i^{(m)})$	2.62 [0.270]	1.95 [0.376]	1.99 [0.368]
Strong exogeneity for $(\Delta i^{(n)})$	11.06*** [0.004]	16.05*** [0.000]	13.80*** [0.001]

Estimated VECMs are specified as follows:
$\Delta\, i^{(m)}_t = \delta_1 + \gamma_1 RES_{t-1} + \text{lagged}(\Delta i^{(m)}_t\,,\ (\Delta i^{(n)}_t\,) + \varepsilon_{1t}$
$\Delta\, i^{(n)}_t = \delta_2 + \gamma_2 RES_{t-1} + \text{lagged}(\Delta i^{(m)}_t\,,\ (\Delta i^{(n)}_t\,) + \varepsilon_{2t}$
Numbers in parentheses below estimated parameters values are t-statistics.
Numbers in square brackets behind Wald statistics are marginal significance levels.
*** indicates significance at the 1% level.

The short-term interest rate is therefore weakly exogenous in all bilateral VECMs describing the dynamics of the Malaysian term structure. Since $i^{(m)}_t$ can be interpreted as a proxy for the short-term policy rate, this result implies that monetary impulses from the policy rate are efficiently transmitted to the whole spectrum of asset returns.

It is interesting to observe that these findings stand in sharp contrast with those recorded for the Malaysian term structure during earlier periods, which supported the long-to-short version of the expectations hypothesis with longer-term rates playing a greater role as equilibrium attractors (Ghazali and Low, 2002). Quantitative estimates of γ_2, moreover, suggest a faster adjustment speed for spreads at shorter maturities, in line with similar evidence obtained for other emerging economies (e.g. Tronzano, 2015a and 2015b).

The third and fourth lines of Table 3 report the values of the LR statistic for standard Granger-Sims causality tests.

At all spread maturities, the LR test is never statistically significant, neither in the equation normalized on the short-term policy rate ($\Delta\ i^{(m)}_t$), nor in that normalized on long-term interest rates ($\Delta\ i^{(n)}_t$ for n = 2, 3, 4). Overall, these results point out the absence of significant short-run causal relationships from short to long-term interest rates or in the reverse direction.

The last row of Table 3, finally, reports the values of the Wald test for the joint null of absence of significant effects arising from the error correction term and from lagged variables in each VECM equation. At all spread maturities, this statistic is not significant in the VECM equation normalized on the short-term policy rate ($\Delta\ i^{(m)}_t$). This joint null is instead consistently rejected in VECM equations normalized on long-term interest rates at all temporal horizons ($\Delta\ i^{(n)}_t$ for n = 2, 3, 4). These findings provide robust support for the strong exogeneity of the short-term policy rate.

To sum up, the empirical investigation of this section detects a significant long-run causal relationship from short to long-term interest rates, overturning some results obtained in the previous literature; moreover it documents the absence of short-run bi-directional causal relationships between nominal yields at different maturities.

3.3 Monetary Policy Implications

The empirical evidence of previous sections has interesting implications as regards a monetary policy strategy relying on the control of a short-term interest rate.

The strong exogeneity of $i^{(m)}_t$ lends substantial support for the adoption of this approach, since it ensures that monetary impulses are efficiently transmitted along the term structure from short to long-term maturities, in line with the conventional view of the monetary transmission mechanism. Although the existence of short-to-long causality in nominal yields contrasts with some evidence for the pre-crisis period, this result is closely in line with more recent research pointing out that Malaysian monetary authorities can effectively target a short-term interest rate instrument to monitor long-term rates and macroeconomic fundamentals (Elshareif and Tan, 2010). The absence of bi-directional causal relationships between nominal yields, documented in the present paper, strengthens this conclusion since monetary policy implementation is not complicated by potential feedbacks from long to short-term interest rates.

Although this evidence is broadly supportive of a monetary policy based on short-term interest rates management, the results of section 3.1 suggest some potential limitations of this approach in the Malaysian context.

The main problem is related to the uncertainty about the validity of the "symmetry" restrictions. The uncertainty about the existence of equi-proportional movements of nominal yields along the term structure complicates the implementation of monetary policy, since the effects of a given monetary policy stance on the ultimate policy targets cannot accurately be predicted. Therefore, although causality runs in the "right" direction, final monetary targets might, at times, significantly depart from their optimal levels[7].

The uncertainty about the validity of the "symmetry" restrictions calls for a gradualist approach in monetary policy implementation. Interest rate smoothing is currently a largely diffused practice among Central Banks for various reasons. In the case of Malaysia, a gradual adjustment of the policy rate deserves particular attention mostly in the light of the degree of uncertainty surrounding the quantitative impact of short rates on longer term yields.

Moreover, since the adjustment to long-run equilibrium is relatively faster for spreads at shorter maturities, the Central Bank should mainly focus on medium-term monetary targets rather than on yields at longer time horizons.

A further problem related to the findings of this paper is related to the nature of risk premium components. The empirical investigation of section 3.1 shows that the "Pure" version of the EHTS is strongly rejected by data and that, in line with the predictions of the "Liquidity Premium" version of this theory, there are significant risk premium components whose quantitative relevance monotonically rises as the time horizon increases. The existence of term premium components is usually motivated on the basis of liquidity preference or hedging behaviour.

One basic assumption of the "Liquidity Premium" version of the EHTS is that the risk premium, although maturity-dependent (i.e. monotonically increasing at longer spread maturities) is time-invariant. If this assumption holds, the feasibility of a monetary strategy based on a short-term instrument is ensured, provided that the Central Bank can adequately predict the impact of the short-

[7] This is obviously most likely during periods in which co-movements of nominal yields tend to become looser such as, in the present sample, at the end of 2004 or at the beginning of 2009 (see the discussion in section 3.1).

term policy rate on longer nominal yields. In this case, the final monetary target incorporates the effects of an exogenous monetary impulse and a (constant) component reflecting risk or liquidity preference considerations.

The assumption of time-invariant risk premium components may, however, be rather unrealistic in many circumstances, since term premia are potentially influenced by many factors including business cycle dynamics, financial markets developments, and various real and financial shocks. If risk premia are time-varying, and if their movements become significant, the implementation of a monetary policy based on a short-term interest rate instrument is clearly more problematic, because the transmission of monetary impulses is disturbed by large unpredictable components, particularly at the longer term end of the yield curve. Note, at this purpose, that the uncertain support for the unbiasedness assumption, documented in section 3.1, can be interpreted as indirect evidence of a time-varying risk premium.

The cointegration analysis performed in this paper is however unable to properly deal with this issue, since the θ_{nm} parameters included in the cointegrating vectors provide simple estimates of (constant) time premia components.

Therefore, in order to reach more robust conclusions about the effectiveness of a short-term rate instrument, the empirical investigation needs to be extended including additional factors, as suggested in Dai and Singleton (2002) and in more recent contributions exploring the effects of macroeconomic fundamentals on term structure dynamics (e.g. Ang and Piazzesi, 2003; Diebold *et al.*, 2006).

4. Further evidence

This section provides further evidence about the dynamics of the Malaysian term structure. Drawing on the cointegrating VAR model identified in section 3, I implement a Forecast Error Variance Decomposition analysis and estimate Impulse Response Functions and Persistence Profiles of the effect of a system-wide shock to cointegrating vectors.

4.1 Forecast Error Variance Decomposition

This analysis complements causality tests carried out in section 3.2. Actually, while the standard VECM approach is a within-sample causality test, the variance decomposition technique is an out-of-sample test, providing additional information about the degree of exogeneity or endogeneity of each variable.

The k-step ahead forecast error variance of each nominal interest rate is decomposed in the percentage due to its own shocks and in that due to innovations in other variables. A variable is relatively more exogenous if its forecast error variance is mostly explained by its own past shocks than by shocks in other variables.

Table 4 reports orthogonalized forecast error variance decompositions for $i^{(1)}$, $i^{(2)}$ and $i^{(4)}$ up to a 8-month ahead forecast horizon[8].

The most salient feature of Table 4 is the predominant role of shocks to the short-term rate ($i^{(1)}$) in explaining forecast error variances for all nominal yields at all forecast horizons.

The percentage of variance explained by innovations in $i^{(1)}$ is extremely high for shorter term nominal yields (1-year, 2-year interest rates) and oscillates around 0.99-0.80. This percentage remains substantially high also in the case of longer term yields, where shocks to $i^{(1)}$ retain a predominant influence in explaining forecast error variances at all temporal horizons (with weights around 0.60 in the case of $i^{(3)}$, and around 0.40 in the case of $i^{(4)}$). A further variable whose innovations exert an appreciable influence on forecast error variances is $i^{(2)}$, particularly as regards medium and long term interest rates. At all forecast horizons, however, the percentage of variance explained by shocks to $i^{(2)}$ is much lower than that explained by shocks to $i^{(1)}$.

Overall, this evidence points out that these short-term nominal yields are the most exogenous variables in the VAR system, although the degree of relative exogeneity of $i^{(1)}$ is much higher.

These results are fully in line with those of the previous section, documenting a robust short-to-long causal relationship between nominal yields and the strong exogeneity of $i^{(1)}$ which, in the present paper, represents a proxy for the short-term policy rate.

[8] The results for the 3-year nominal yield are not included for space reasons. These results are however broadly similar to those for the 4-year interest rate, the only relevant exception being that the percentage of variance explained by innovations in $i^{(4)}$ is much smaller in the case of the 3-year nominal yield.

Table 4 - *Malaysian Term Structure*

Orthogonalized Forecast Error Variance Decomposition for $i^{(1)}$

Horizon	$i^{(1)}$	$i^{(2)}$	$i^{(3)}$	$i^{(4)}$
0	1.000	0.000	0.000	0.000
1	0.994	0.005	0.2E-4	0.4E-3
2	0.988	0.010	0.6E-3	0.5E-3
3	0.983	0.014	0.001	0.8E-3
4	0.979	0.017	0.002	0.001
5	0.976	0.020	0.002	0.001
6	0.973	0.023	0.002	0.001
7	0.970	0.025	0.002	0.002
8	0.968	0.027	0.002	0.002

Orthogonalized Forecast Error Variance Decomposition for $i^{(2)}$

Horizon	$i^{(1)}$	$i^{(2)}$	$i^{(3)}$	$i^{(4)}$
0	0.729	0.270	0.00	0.00
1	0.774	0.203	0.006	0.017
2	0.783	0.181	0.006	0.030
3	0.788	0.168	0.006	0.036
4	0.793	0.159	0.007	0.040
5	0.797	0.153	0.007	0.042
6	0.801	0.148	0.007	0.043
7	0.804	0.143	0.007	0.043
8	0.808	0.140	0.007	0.044

Orthogonalized Forecast Error Variance Decomposition for $i^{(4)}$

Horizon	$i^{(1)}$	$i^{(2)}$	$i^{(3)}$	$i^{(4)}$
0	0.353	0.341	0.117	0.187
1	0.367	0.323	0.092	0.215
2	0.380	0.318	0.073	0.226
3	0.394	0.314	0.062	0.228
4	0.409	0.310	0.054	0.225
5	0.424	0.306	0.049	0.221
6	0.438	0.301	0.045	0.215
7	0.452	0.296	0.042	0.209
8	0.465	0.290	0.039	0.204

4.2 Generalized Impulse Response Functions and Persistence Profiles

I now analyze the estimates of Generalized Impulse Response Functions (GIRFs). In line with the analysis of previous sections, the underlying cointegrating VAR has a lag order of two (p = 2), assumes the existence of three cointegrating vectors (r = 3), and is estimated imposing the "symmetry" restrictions.

Figures 2, 3, 4 and 5 display, respectively, GIRFs to one standard deviation shock in the equations for $i^{(1)}$, $i^{(2)}$, $i^{(3)}$ and $i^{(4)}$.

FIGURE 2 - *Generalized Impulse Response(s) to one S.E. Shock in the Equation for M1Y*

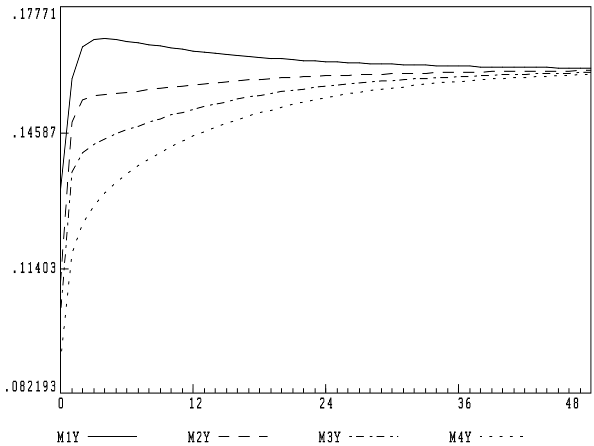


FIGURE 3 - *Generalized Impulse Response(s) to one S.E. Shock in the Equation for M2Y*

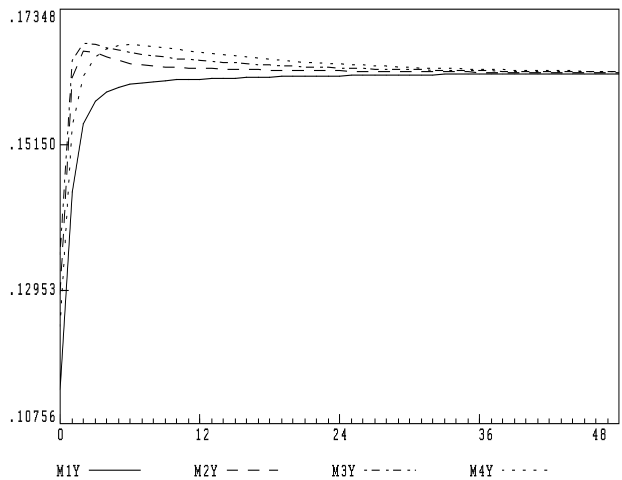


FIGURE 4 - *Generalized Impulse Response(s) to one S.E. Shock in the Equation for M3Y*

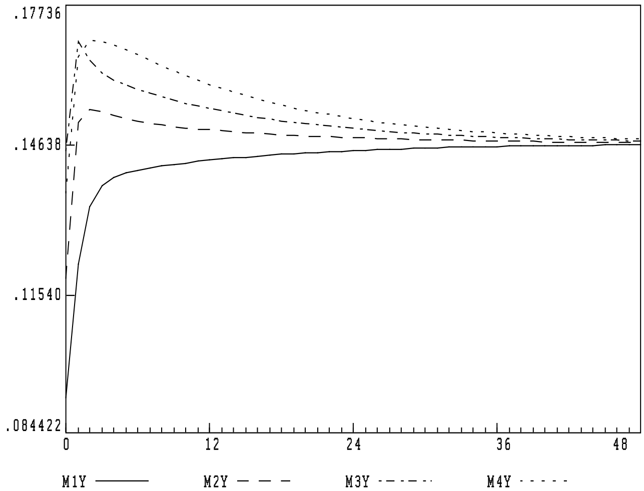
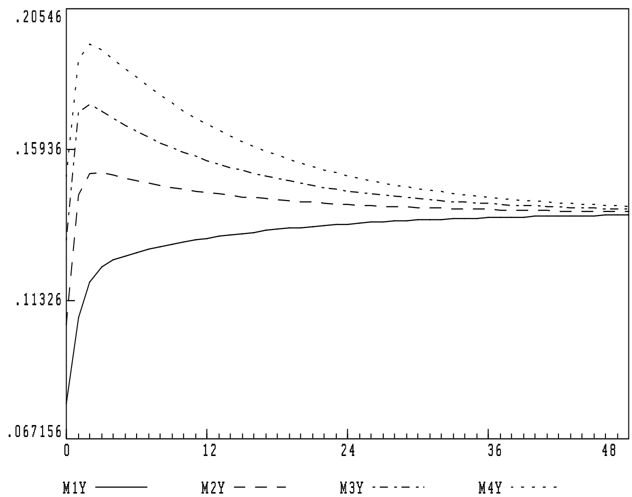


FIGURE 5 - *Generalized Impulse Response(s) to one S.E. Shock in the Equation for M4Y*



The response of yields at all maturities is always significant and highly persistent. Full convergence to new steady-state values takes about four years although, as revealed by these figures, the bulk of the adjustment process is completed in about two years.

Although this approach cannot provide direct inferences about the causal order among variables, the adjustment paths of nominal yields are consistent with previous empirical findings.

Consider the responses to a one standard error shock to $i^{(1)}$ (Figure 2). This short-term rate displays the largest reaction on impact, whereas other nominal yields display milder reactions, with decreasing intensity as the maturity of the involved asset increases (i.e. progressively lower for $i^{(2)}$, $i^{(3)}$ and and $i^{(4)}$). Consider now the adjustment patterns to a one standard error shock to longer-term nominal yields $i^{(3)}$ and and $i^{(4)}$ (Figures 4 and 5). The intensity of various responses is now clearly reversed. The short-term (policy) rate displays the weakest reaction on impact, whereas longer-term rates exhibit the stronger responses, overshooting their equilibrium values for most of the adjustment process.

Overall, this evidence is broadly consistent with the strong exogeneity of $i^{(1)}$, documented in section 3.2, as well as with the relatively higher degree of exogeneity of short-term yields documented in section 4.1.

I finally consider the persistence profiles of cointegrating vectors following a system-wide shock to the term structure. This analysis provides visual evidence about the speed of adjustment of the cointegrating relationships, thus usefully complementing VECM estimates discussed in section 3.2.

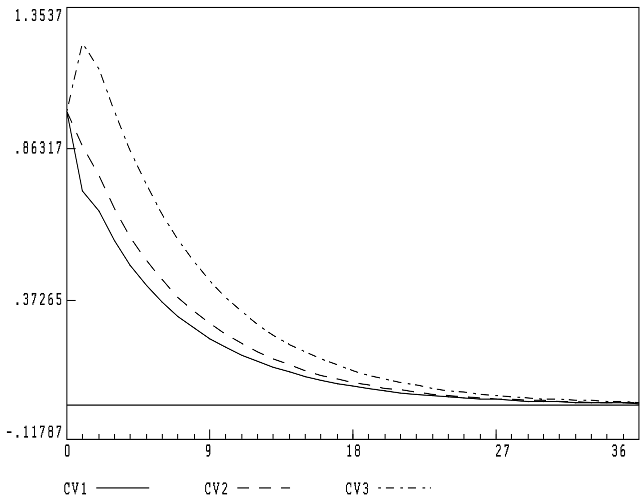
The persistence profiles of cointegrating vectors up to a three-year time horizon are shown in Figure 6.

The first cointegrating vector (CV1) corresponds to the equilibrium relationship between the short-term (policy) rate (i_1) and the 2-year government bond yield (i_2). The remaining cointegrating vectors correspond to the equilibrium relationships between (i_1) and longer-term maturities i.e., respectively, i_3 (CV2) and i_4 (CV3).

The effects of a system-wide shock are progressively dissipated over time, confirming the existence of cointegration between the short-term rate and yields at longer maturities. Overall, for all cointegrating vectors, the largest part of the adjustment path is completed between two and three years.

A closer inspection of Figure 6 reveals, however, significant differences in the adjustment speeds. More specifically, the cointegrating vector corresponding to the shorter spread maturity (CV1) exhibits a faster convergence towards equilibrium, whereas the cointegrating vectors associated with larger maturities display a slower response (particularly as regards CV3).

FIGURE 6 - *Persistence Profile of the Effect of a System-Wide Shock to CV'(s)*



This evidence is similar to that usually reported for industrial and emerging market economies (see respectively, among others, Masih and Ryan, 2005 and Tronzano, 2015b). These results, moreover, are closely in line with the empirical findings of section 3.2, documenting that estimated error correction parameters are significant and quantitatively higher for shorter spreads maturities, and decrease monotonically for larger spreads maturities.

A further interesting feature of Figure 6 is the peculiar path of the cointegrating vector relative to the longer spread maturity (CV3) during the months immediately following the shock. While other persistence profiles exhibit a monotonic adjustment, CV3 displays an overshooting path before converging to the long-run equilibrium.

This overreaction captures a greater instability of longer term nominal yields, indicating that the market is more uncertain about the effects of a shock at the longer edge of the maturities spectrum. At the same time, this overshooting pattern points out a tendency of long-term interest rates to be more volatile, in line with the descriptive statistics of nominal interest rates for this sample period.

5. Concluding remarks

This paper investigates the EHTS for Malaysia using monthly data on government bond yields since the end of the 1990's. This country represents an interesting case-study, given its long-lasting process of financial deregulation begun in the early 1970's and progressively extended during the following decades.

The present research contributes to the existing literature in two main directions.

First, I rely on a multivariate approach for cointegration testing. A simultaneous analysis of the long-run equilibrium relationships delivers more robust statistical inferences, since term structure innovations jointly affect the whole spectrum of interest rates maturities (Hall *et al*., 1992; Engsted and Tanggaard, 1994).

Second, drawing on this multivariate framework, I assess some important restrictions on the parameters of cointegrating vectors. Although disregarded in the existing literature, this analysis provides useful information about the long-run dynamics of the interest rates system, and is important in order to evaluate the feasibility of a monetary strategy relying on a short-term interest rate instrument.

The main empirical findings may be summarized as follows.

I document the existence of three cointegrating vectors in a four-dimensional system of nominal interest rates. This result supports the EHTS, since one relevant testable implication of this theory is that a system of two or more non-stationary variables is driven by one common stochastic trend.

Likelihood ratio tests of joint restrictions on cointegrating vectors produce mixed results. The "symmetry" restrictions are partially supported by the empirical evidence (not rejected at a 1% confidence level, but rejected at less restrictive significance levels). The joint restrictions of "symmetry" and "zero risk premia" are instead strongly rejected, thus not supporting the "Pure" version of the EHTS. Estimated cointegrating vectors disclose significant risk premia components, whose quantitative relevance increases monotonically with the maturity structure, in line with the predictions of the "Liquidity Premium" theory.

Causality tests in a VECM framework point out that the short term interest rate is strongly exogenous, in sharp contrast with some evidence for earlier periods supporting the long-to-short version of the EHTS.

Further evidence relying on forecast error variance decomposition, impulse response functions and persistence profiles corroborates the above results, both as regards the exogeneity of variables, and as regards the adjustment speeds of various spread maturities towards the long-run equilibrium.

Overall, this research has interesting implications for the implementation of a monetary policy based on a short term interest rate instrument.

The main results from VECM causality tests are clearly supportive of this policy, since the strong exogeneity of the short term rate (interpreted as a proxy for the policy rate) implies that monetary impulses are effectively transmitted along the yield curve. The implementation of an interest rate based monetary policy deserves, however, some qualifications on the basis of other results obtained in this paper.

The uncertain support for the "symmetry" restrictions implies that the long-run effects of monetary impulses are relatively more difficult to quantify in the Malaysian context. This uncertainty calls for a more gradualist approach in the management of the short-term policy rate, in order to smooth out the unforeseen effects of monetary policy. A further potential problem is represented by the existence of significant risk premia components. If these components are maturity-dependent but time-invariant, as the "Liquidity Premium" theory assumes, there are no additional problem in monetary policy implementation. However, since the assumption of a constant risk premium is questionable for various reasons, further research is needed to provide a more accurate evaluation about the feasibility of an interest rate based monetary policy.

This paper can be extended along various research lines. Some straightforward extensions, in order to assess the robustness of empirical findings, include the use of higher frequency data, the increase in the number of assets maturities, and the analysis of nominal yields relative to other financial instruments.

Other research topics, departing more significantly from the methodological framework of this paper, involve the use of cointegration tests allowing for one or more structural breaks, and the adoption of panel cointegration techniques.

Cointegration tests with structural breaks would allow to extend the analysis for Malaysia on a wider sample, possibly incorporating the effects of macroeconomic shocks or of changes in the policy regime. Panel cointegration tests would instead allow a joint analysis of the EHTS on a relevant group of Asian countries, with a significant increase in tests power with respect to a single-country approach.

Finally, as mentioned before, a more accurate investigation about the nature of risk premia is crucial to better qualify the monetary policy implications of this research. The recent literature exploring the effects of macroeconomic fundamentals on term structure dynamics (see, among others, Ang and Piazzesi, 2003; Diebold *et al.*, 2006) could greatly help in this regard, as documented in some recent contributions including macroeconomic variables as conditioning information in a general VAR specification (Sarno *et al.*, 2007).

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ABSTRACT

This paper tests the Expectations Hypothesis of the Term Structure (EHTS) for Malaysia during the period following the Asian financial crisis. A multivariate cointegration approach provides evidence favorable to the EHTS, notwithstanding the uncertain support for the "symmetry" restriction and the existence of significant risk premia at all maturities. Causality tests reveal, moreover, that the short-term interest rate is strongly exogenous.

Overall, these results are consistent with a policy based on a short-term interest rate instrument, albeit with some relevant qualifications related to the need of a gradualist approach in monetary policy implementation and of further research about the nature of term premia components.

Keywords: Term Structure of Interest Rates, Cointegration, Monetary Policy, Malaysia

JEL Classification: E43, E52

RIASSUNTO

La struttura a termine dei tassi di interesse nei paesi emergenti: alcune evidenze empiriche nel caso della Malaysia (1999-2015)

L'articolo analizza la validità della "Expectations Hypothesis" sulla struttura a termine dei tassi di interesse in Malaysia nel periodo successivo alla crisi finanziaria asiatica. L'evidenza empirica prodotta da un approccio di cointegrazione multivariata è favorevole a tale ipotesi, nonostante un supporto incerto per la restrizione di simmetria e l'esistenza di significative componenti di premio per il rischio a tutte le scadenze. I tests di causalità, inoltre, mostrano che il tasso di interesse a breve è fortemente esogeno. Nel complesso, questi risultati sono favorevoli all'utilizzo di una politica monetaria basata sul controllo del tasso di interesse a breve, pur suggerendo la necessità di un approccio graduale nell'implementazione di tale politica e l'esigenza di ulteriori ricerche sulla natura delle componenti di premio per il rischio.