

# **An Empirical Analysis of the Bond Market Behavior and Cointegration in the Selected APEC's Countries**

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## **Abstract**

This article examines the behavior of Treasury bond rates in Asia-Pacific Economic Cooperation's countries. Granger causality tests based on the vector error correction model (VECM) suggest bidirectional Granger causalities between changes in (i) the Canadian and Malaysian Treasury bond rates, (ii) the Canadian and New Zealand bond rates, (iii) the US and Malaysian Treasury bond rates, and (iv) the South Korean and Malaysian Treasury bond rates. The results also reveal unidirectional Granger causalities from changes in (i) the Canadian to US Treasury bond rates, (ii) the South Korean to New Zealand and US Treasury bond rates, (iii) the Malaysian to New Zealand and Thai Treasury bond rates, (iii) the Thai to New Zealand and South Korean Treasury bond rates, and (iv) the US to New Zealand Treasury bond rates. The Granger causality test based on the augmented vector autoregressive (VAR) procedure yields largely similar results from VECM. These empirical findings may be attributable to differences in economic policies, governance, culture, and other institutional arrangements in each of these countries. The empirical results are important for investors and traders since they can use past information in one country to predict prices and returns in the future in other countries.

**JEL classification codes:** C22, F36, G14

**Keywords:** Treasury bond rates, APEC's countries, Johansen cointegration test, TYDL augmented VAR procedure.

## **1 Introduction**

Recent modern technological advances in telecommunications, transportation, the internet, and production computerization have facilitated rapid acceleration in world trade and

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travel, the flow of goods and services, and the flow of financial assets among different countries. The volume of international trade which is highlighted by exponential growth in the international flow of financial assets has been fueled by adherence to post-World War II neoclassical export development as well as greatly increased membership and participation in the World Trade Organization.

Asia-Pacific Economic Cooperation (APEC) was formed in 1989 in Canberra Ministerial Meeting in response to the growing interdependence among Asia-Pacific economies. Begun as an informal dialogue group with limited participation, APEC has since become the primary regional vehicle for promoting open trade and practical economic cooperation. Its goal is to advance Asia-Pacific economic dynamism and sense of community. Today, APEC includes all the major economies of the region and the most dynamic, fastest growing economies in the world. APEC's 21 member economies account for approximately 40% of the world's population, approximately 54% of the world's gross domestic product and about 44% of world trade.

APEC's countries have experienced large-scale growth in international trade which has been the result of new technologies, enhanced economic efficiency and increased international investment opportunities. With the advent of greatly improved worldwide capital mobility, APEC's countries now present highly profitable investment opportunities to investors seeking the most lucrative rates of return on a worldwide basis. Additionally, in perfectly efficient markets, new information is reflected in all markets simultaneously; however, markets in most of emerging and developing economies are hardly efficient. Therefore, the nature of Granger causalities among these equity markets and between these markets may allow investors and traders to use past information in one country to predict prices or returns in the future in other countries (Floros 2011, p. 227).

Among APEC's 21 current member countries, International Monetary Fund's databases contained complete time series data on public bond rates for only Australia, Canada, Japan, South Korea, Malaysia, New Zealand, Thailand, and the United States over the period 1995:01 to 2011:10. Furthermore, the augmented Dickey-Fuller and Phillip-Person unit root tests suggest the rejection of the presence of unit roots in levels for the Australian and Japanese time series, i.e., they are stationary over the sample period. Due to data limitations and stationarity of the aforementioned series, this study can only examine the cointegrating behavior of the Treasury bond rates in Canada, South Korea, Malaysia, New Zealand, Thailand, and the United States.

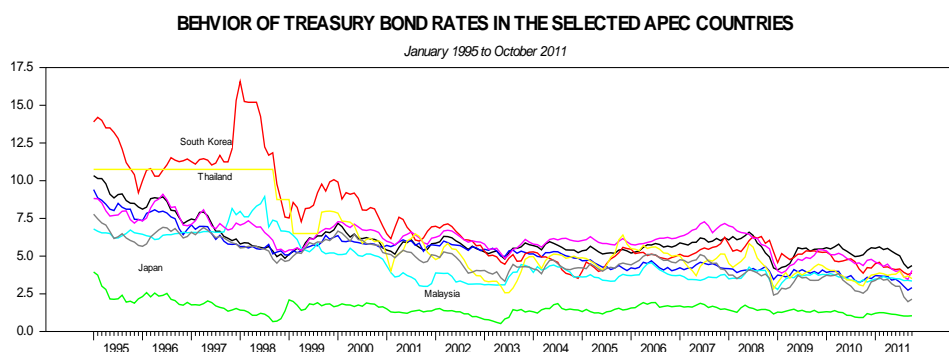
The sample period was selected partly to assure the availability of sufficient and complete time series data and partly to cover the period since the Bogor Goals were implemented (Bogor is the name of the city in Indonesia where APEC's leaders adopted the Bogor Goals in 1994). During this period, APEC has started to enlarge the areas of economic and technical cooperation. There are two milestones in this period. The first is the 1995 Osaka Action Agenda in the seventh Ministerial meeting, which introduced a blueprint for liberalization and facilitation of trade and investment for carrying out economic and technical cooperation among APEC's members. The second is the 1996 Manila Action Plan for APEC in the Eighth Ministerial Meeting, which included both a collective action plan and individual action plans of all 18 members at that time, as well as general guidelines to govern these plans. The Bogor Goals aim for free and open trade and investment in the Asia-Pacific by 2010 for industrialized economies and by 2020 for developing economies. Also in 1995, APEC established a business advisory body named the APEC Business Advisory Council (ABAC), composed of three business executives from each member economy.

In addition to being APEC's members, economically advanced APEC's economies share many common features as developed economies; thus, the yields on their respective public bonds are expected to be cointegrated. However, it is also reasonable to conjecture that differences in national economic policies, governance, culture, and other institutional arrangements in each of these countries may result in different bond holding risk profiles. Different bond risk profiles may cause the yield on these bonds to be different and independent among seemingly similar economies. Thus, it is worthwhile to empirically investigate differences in Treasury bond rate behavior in APEC's countries.

## 2 The Data and Methodology

### 2.1 Data

This study uses available Treasury bond rates in the selected APEC's countries. The monthly data set covers the period 1995:01 to 2011:10. The Treasury bond rates for Canada, South Korea, Malaysia, New Zealand, Thailand, and the United States are denoted by CA, KR, MY, NZ, TH, and US; while the stationary series for Australia and Japan are denoted by AU and JP, respectively. All time-series data are collected from the International Financial Statistics, published by the International Monetary Fund.



**Figure 1:** Treasury bond rates in the selected APEC countries.

Figure 1 displays the behavior of the respective Treasury bond rates of the above selected economies over the sample period. A close examination of figure 1 suggests cointegrating movements among Treasury bond rates.

### 2.2 Methodology

In order to apply the augmented VAR[ $k+d(max)$ ] model, developed by Toda and Yamamoto (1995) and Dolado and Lütkepohl (1996) (TYDL), the lag order of the original VAR( $k$ ) and the order of cointegration,  $d(max)$ , must be determined. As to the maximum order of integration of the time series in question,  $d(max)$ , two standard unit root tests were conducted: the augmented Dickey-Fuller (1979) and Phillip-Perron (1988) tests. The null hypothesis for both tests is that a unit root exists in the autoregressive representation of the series. The augmented Dickey-Fuller and Phillip-Person unit root test results are reported in Table 1. An analysis of the test results suggests the presence of unit roots in levels for all series, except for AU and JP. Therefore, AU and JP series are

excluded in subsequent analyses. All series with unit roots in levels are stationary after first differencing. These findings indicate that the remaining time series under consideration are non-stationary and integrated of order I(1).

Table 1: ADF and PP test results, APEC's Countries, Data-1995:01 to 2011:10

Series	<u>Augmented Dickey - Fuller</u>		<u>Phillip - Person</u>	
	Level	First Differencing	Level	First Differencing
AU	-3.4041**	NA	-3.4348**	NA
CA	-2.6802	-15.5048*	-2.7430	-15.5048*
JP	-5.5380*	NA	-5.5047*	NA
KR	-2.0443	-10.1424*	-2.0567	-10.2394*
MY	-1.5783	-14.0453*	-1.5602	-14.0485*
NZ	-2.7318	-9.6013*	-2.1992	-9.3284*
TH	-1.5948	-11.5647*	-1.5170	-11.4944*
US	-1.8387	-11.4205*	-1.8674	-11.4461*

**Note:** \* and \*\* denote rejections of the hypothesis at the 1 and 5 percent levels respectively.

The lag order of the original VAR model,  $k$ , can be determined by using several lag order selection criteria such as the sequential modified LR test statistic (LR), final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SIC), and Hannan-Quinn information criterion (HQ). The results of the lag selection procedure are summarized in Table 2. As to the best criteria, Khim and Liew (2004, p. 5) articulate that for a sample data containing up to 120 observations, AIC, SIC, FPE, HQC and BIC have under-estimated the true lag length with a probability falling in the range of 0.289 and 0.473 inclusively. On the other hand, the probability of under estimation reduces as sample size grows, to an acceptable extent for a sample size as large as 960, with a respective probability of 0.128, 0.192, 0.128, 0.151 and 0.182. These authors further articulate that as researchers hardly have large sample, identifying the criterion that minimizes the probability of under estimation may be a more practically effort. In this regards, the authors report that AIC and FPE consistently out-do the rest across all sample sizes. Thus, they suggest that if the objective is to avoid too low the lag length being selected, it is advisable to adopt AIC and/or FPE. Moreover, the gain in choosing of these two criteria is even significant in sample size of not more than 60 observations. In such ideal case, apart from minimizing the chance of under estimation, the authors articulate that these criteria can simultaneously maximize the chance of getting the correct lag length. They posit that their conclusion may be taken as formal statistical support for the well-liked use of AIC criterion in previous empirical studies. The aforementioned FPE and AIC suggest using a lag of three. Subsequent analysis therefore proceeds with the use of VAR with lag length  $k=3$ .

Table 2: Maximum Lag length, APEC’s Countries, Monthly Data 1995:01 to 2011:10

Lag	Log L	LR	FPE	AIC	SIC	HQ
0	-1419.359	NA	0.072101	14.39757	14.49721	14.43790
1	-47.83610	2646.070	9.98e-08	0.907435	1.604947*	1.189765
2	39.73480	163.6426	5.94e-08	0.386517	1.681895	0.910843*
3	80.50811	73.72144	5.67e-08*	0.338302*	2.231547	1.104624
4	113.7976	58.17252*	5.85e-08	0.365681	2.856792	1.374000

**Note:** \* indicates lag order selected by the criterion.

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SIC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Additionally, Engle and Granger (1987) articulated that if two series are integrated of order one, I(1), there is need to test for the possibility of a long-run cointegrating relationship among the variables. Since the cointegration and error correction methodology is well documented elsewhere (Engle and Granger 1987; Johansen and Juselius 1990; Banerjee et al. 1993) only a brief overview is provided here. Johansen and Juselius’ (1990) multivariate cointegration model is based on the error correction representation given by:

$$\Delta X_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \varepsilon_t \tag{1}$$

where  $X_t$  is an  $(n \times 1)$  column vector of  $p$  variables,  $\mu$  is an  $(n \times 1)$  vector of constant terms,  $\Gamma$  and  $\Pi$  represent coefficient matrices,  $\Delta$  is a difference operator,  $k$  denotes the lag length, and  $\varepsilon_t \sim N(0, \Sigma)$ . The coefficient matrix,  $\Pi$ , is known as the impact matrix, and contains information about the long-run relationships. Johansen and Juselius’ (1990) methodology requires the estimation of the VAR equation (1), and the residuals are then used to compute two likelihood ratio (LR) test statistics that can be used in the determination of the unique cointegrating vectors of  $X_t$ . The number of cointegrating vectors can be tested for using two statistics: the trace test and the maximal eigenvalue test. The testing results are reported in Table 3.

As shown in Table 3, the calculated Trace- statistics suggest the existence of, at most, one cointegrating vector. This implies the presence of four independent common stochastic trends in this system of five variables.

Table 3: Johansen cointegration test results, APEC's Countries, 1995:01- 2011:10

Number of cointegrating vectors	<u>Trace Statistics</u>		<u>Max-Eigen Statistics</u>	
	Statistics	C (5%)	Statistics	C (5%)
$r \leq 0$	122.7306*	95.75366	61.98756*	40.07757
$r \leq 1$	60.74304	69.81889	23.40471	33.87687
$r \leq 2$	37.33833	47.85613	17.10880	27.58434
$r \leq 3$	20.22953	29.79707	9.910107	21.13162
$r \leq 4$	10.31942	15.49471	6.733897	14.26460

**Note:** \* denotes rejection of the hypothesis at the 5 percent level.

Moreover, the augmented VAR procedure, proposed by Toda and Yamamoto (1995) and Dolado and Lütkepohl (1996), complements the VECM technique because it allows for causal inference based on an augmented level VAR with integrated and cointegrated processes. The dynamic causal relationships among the Treasury bond rates in the selected APEC's countries are examined, using the following VAR in level specification:

$$X_t = \mu + \sum_{i=1}^{p-1} \Gamma_i X_{t-k} + \zeta_t \quad (2)$$

where  $X_t$  is an  $(n \times 1)$  column vector of  $p$  variables,  $\mu$  is an  $(n \times 1)$  vector of constant terms,  $\Gamma$  represents coefficient matrices,  $k$  denotes the lag length, and  $\zeta_t$  is *i.i.d.* and  $p$ -dimensional Gaussian error with mean zero and variance matrix  $\Lambda$ .

As pointed out by Awokuse (2005-a, p. 695), the TYDL procedure uses a modified Wald test for the restriction on the parameters of the VAR( $k$ ) model. This test has an asymptotic chi-squared distribution with  $k$  degrees of freedom in the limit when a VAR[ $k+d(max)$ ] is estimated, where  $d(max)$  is the maximal order of integration for the series in the system. Awokuse (2005-b, p. 852) further articulates the attraction of the TYDL approach in that prior knowledge about cointegration and testing for unit root are not necessary once the extra lags, i.e.,  $d(max)$  lags, are included. Given that VAR( $k$ ) is selected, and the order of integration  $d(max)$  is determined, a level VAR can then be estimated with a total of  $p=[k+d(max)]$  lags. Finally, the standard Wald tests are applied to the first  $k$  VAR coefficient matrix (but not all lagged coefficients) to make a Granger causal inference.

### 3 Empirical Results

Based on the above determined appropriate lag length  $k=3$  and the  $d(max) = 1$ , the Granger causality test results using both the VECM and the augmented level VAR specifications are reported in Table 4.  $F$ -statistics and  $p$ -values (in parentheses) for Granger causality tests from the VECM specification are presented in Table 4(a).

The empirical results of the VECM [see panel (a) of Table 4] reveal bidirectional Granger causalities between changes in (i) the Canadian and Malaysian Treasury bond rates, (ii) the Canadian and New Zealand bond rates, (iii) the US and Malaysian Treasury bond rates (iv) the South Korean and Malaysian Treasury bond rates. These bidirectional Granger causalities indicate that Treasury bond rates in these countries are cointegrated, i.e., their movements affect one another, directly or otherwise. Additionally, judging by

the  $p$ -values, the direct pairwise linkages between the Treasury bond rates in the countries in the same geographic area or across the Pacific Ocean are strong. These empirical findings suggest the internationalization and the regional trade agreement have linked financial markets of international economies together.

Table 4: Granger causality test results, APEC's Countries, Monthly Data-1995:01 to 2011:10

<b>(a) Results based on error correction model (ECM)</b>						
Dep.	Short run lagged differences ( $F$ -statistics)					
Variables	$\Delta CA$	$\Delta KR$	$\Delta MY$	$\Delta NZ$	$\Delta TH$	$\Delta US$
$\Delta CA$	-	0.5117(0.6742)	2.9473(0.0315)	2.5979 (0.0505)	1.1696 (0.3196)	1.4431 (0.2280)
$\Delta KR$	1.3776 (0.2475)	-	5.3240 (0.0011)	0.6588 (0.5773)	2.5180 (0.0562)	1.1271 (0.3365)
$\Delta MY$	2.2330 (0.0821)	2.6004 (0.0503)	-	1.0034 (0.3901)	1.1994 (0.3082)	4.2885 (0.0049)
$\Delta NZ$	7.2455 (0.0001)	5.0399 (0.0017)	4.4704 (0.0038)	-	2.5304 (0.0553)	4.3130 (0.0048)
$\Delta TH$	1.1775 (0.3166)	1.0900 (0.3518)	2.9055 (0.0333)	0.3990 (0.7538)	-	0.2626 (0.8524)
$\Delta US$	10.8344 (0.0000)	2.2413 (0.0812)	3.5880 (0.0131)	0.2026 (0.8946)	1.6086 (0.1850)	-
<b>(b) Results based on an augmented VAR model (TYDL procedure)</b>						
Dep.	Modified Wald-statistics					
Variables	CA	KR	MY	NZ	TH	US
<b>CA</b>	-	3.2913 (0.3489)	9.3227 (0.0253)	8.6362 (0.0345)	4.9130 (0.1783)	3.7062 (0.2950)
<b>KR</b>	5.1651 (0.1601)	-	19.4902 (0.0002)	0.9057 (0.8240)	8.7311(0.0331)	4.2431 (0.2364)
<b>MY</b>	6.8276 (0.0776)	16.7828 (0.0008)	-	2.8744 (0.4114)	4.0795 (0.2530)	10.8625 (0.0125)
<b>NZ</b>	25.2431(0.0000)	1.9069 (0.5919)	17.3178 (0.0006)	-	5.4391(0.1423)	9.4391 (0.0197)
<b>TH</b>	3.9242 (0.2698)	5.1350 (0.1622)	10.7248(0.0133)	1.0409 (0.7914)	-	1.3028 (0.7285)
<b>US</b>	38.6928 (0.0000)	3.6621 (0.3003)	12.8587 (0.0050)	0.5597 (0.9056)	2.4540 (0.4837)	-

Notes: The  $[k+d(max)]$ th order level VAR was estimated with  $d(max) = 1$  for the order of integration equals 1.

Lag length selection of  $k=3$  was based on FPE and AIC.

Reported estimates are asymptotic Wald statistics. Values in parentheses are  $p$ -values.

The results reveal unidirectional Granger causalities from changes in (i) the Canadian to US Treasury bond rates, (ii) the South Korean to New Zealand and US Treasury bond rates, (iii) the Malaysian to New Zealand and Thai Treasury bond rates, (iii) the Thai to New Zealand and South Korean Treasury bond rates, and (iv) the US to New Zealand Treasury bond rates. Except for the eliminations of the unidirectional causality from the South Korean to New Zealand Treasury bond rates and two fairly weak causalities from the South Korean to the US and the Thai to New Zealand Treasury bond rates, similar conclusions are found for causality results from the TYDL testing approach [see panel (b) of Table 4]. No other Granger causalities, unidirectional or otherwise were found.

As aforementioned, these empirical findings may be attributed to differences in national economic policies, governance, culture, and other institutional arrangements in each of these

countries, which may result in different bond holding risk profiles. Different bond risk profiles may cause the yield on these bonds to be different and independent among seemingly similar economies. These findings suggest the opportunity for investors and traders to use past information in one country to predict prices and returns in the future in other countries.

#### 4 Concluding Remarks

This study employs recently developed estimation techniques to examine the relationships among the Treasury bond rates in selected APEC's countries. The study focuses on whether Treasury bond rates are cointegrated given the observed similarities of these economies. More specifically, VECM and the augmented level VAR model with integrated and cointegrated processes (of arbitrary orders) developed by Toda and Yamamoto (1995) and Dolado and Lütkepohl (1996) were used to test for Granger causality. Granger causality tests based on the VECM also suggest bidirectional Granger causalities between changes in (i) the Canadian and Malaysian Treasury bond rates, (ii) the Canadian and New Zealand bond rates, (iii) the US and Malaysian Treasury bond rates, and (iv) the South Korean and Malaysian Treasury bond rates. The Granger causality test based on the augmented VAR procedure yields largely similar results from VECM. These empirical findings may be explained by differences in national economic policies, governance, culture, and other institutional arrangements in each of these countries, which may result in different bond holding risk profiles. Different bond risk profiles may cause the yield on these bonds to be different and independent among seemingly similar economies. The empirical results are important for investors and traders since they can use past information from one country to predict prices and returns in the future in another country.

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