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# Detecting the Best Performing Time-Variant Cointegration Test Using the Consumption Function

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## Abstract

An empirical evaluation of five time-variant tests has been made to identify the best-performing cointegration test. According to our results, the majority of the time-varying cointegration tests achieve superior to capture the presence of a long-run relationship for the considered consumption function. However, among all tests, a single test with almost capturing the 100% existence of the long-run relationship is recognized to be the utmost powerful for all model specifications. While a time-varying cointegration test with weak performance to capture the presence of cointegration is identified to be the worst performer test at all specifications.

**Disciplinary**: Econometrics/Financial Economics.



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## 1 Introduction

Cointegration is identified to be the most widespread concept after it has been developed. According to (Granger and Newbold, 1974), two non-stationary series when regress provides spurious results. Further, (Nelson and Plossor, 1982) showed that the majority of the time series follows the non-stationary process. To tackle the problem of spurious regression, Engle and Granger (1987) introduced the concept of cointegration to strengthen the regression based on two non-stationary series and provide a framework to establish the long-run relationship. After that, a lot of cointegration tests, the majority of them are time-invariant, were developed based on different assumptions and mathematical structures in instruction to identify the correct nature of long-run association among the time series variables under investigation. However, Park and Hahn (1999) investigated that cointegration has been less successful and productive in practical

situations indicating the claim of the nonexistence of cointegration rather than presence in the published empirical research work. This indication might be due to misspecification of the models because of the parameters unsteadiness or mislead of the variables used or both. Parameters inconsistency can be more significant, this is because of estimated parameters describing the long-run relationship with respect to data carrying a long span of time. This means that a long span of time is expected not to alter the association if examined. Quintos and Phillips (1993), and Hansen (1992) developed Lagrange Multiplier (LM) tests in the context of parameters dependability in the cointegration regressions.

In view of the literature, it is needed to take into account cointegrating associations which fluctuate over time. Further, cointegrating regressions with respect to time-variant coefficients are produced by the inclusion of the smooth function. In this regard, Fourier flexible form (FFF) functions which contain linear, quadratic and trigonometric functions are the basic smooth functions which are supposed to be time-variant and to be used to model long-run relationship. (Park and Hahn, 1999) presented the very first time-varying coefficients test, residual-based test, in the cointegration regressions. They used the smooth functions changing over time to model the time-varying coefficients. These coefficients are calculated non-parametrically by using the appropriately modified time series of estimators. In the existing literature, many studies have been conducted to recognize best and worst performer time-invariant cointegration tests (Khan and Zaman, 2017; Mariel, 1996; Haug, 1996). Almost all these studies concluded that residual-based tests perform better, tests based on error correction mechanism performs average, while system-based tests perform worst. In this article, four invariant time-series tests of cointegration are modified empirically time varyingly and compared with the one already existing test of Park and Hahn (1999) to detect the best performing test in time-variant dimension.

## 2 Time-Variant Tests and Comparison

In this study, a total of five time-variant tests in Table 1 have been studied and compared.

**Table 1**: The tests that are compared in this study.

| S. No. | Test and Authors | Abbreviated |
|---|---|---|
| 1 | Time-Varying Phillips and Ouliaris (1990) $\widehat{\boldsymbol{Z}}_{\boldsymbol{\alpha}}$ | TVPOZA |
| 2 | Time-Varying Phillips and Ouliaris (1990) $\widehat{\boldsymbol{P}}_{\boldsymbol{U}}$ | TVPOPU |
| 3 | Time-Varying the t-test of Cointegration Banerjee et al. (1986) | TVTECM |
| 4 | Time-Varying Leybourne and McCabe (1994) | TVLM |
| 5 | Time-Varying Park and Hahn (1999) | TVPH |

## 3 Model and Data Description

In this study, we have used the following time-varying consumption function to empirically evaluate the performance of time-variant cointegration tests considered, (Greene, 2002)

$$C_t = \beta_{1t} + \beta_{2t} Y_t + \beta_{3t} i_t + \beta_{4t} C_{t-1} + \varepsilon_t \quad (1),$$

where $Y_t$, $C_t$ and $i_t$ denotes the log of real disposable income, log of real consumption, and interest rate (90-day T bill rate), respectively with the model error $\varepsilon$. The regression model Equation (1)

appears to be appropriate to model long-run relationships with respect to gradually time-varying, as numerous commodities most likely to have such characteristics due to persistent habits among other stuff. As the asymptotic calculation is not much affected if more finite function series is added this indicates that FFF functions contain linear and quadratic functions along with trigonometric functions in the given equation.

Quarterly data is collected from 1961Q1 to 2018Q4 for four countries Japan, Canada, United Kingdom, and South Africa from International Financial Statistics (IFS) data.

## 4 Results and Discussion

To make a comparison empirically and equate test size around the nominal size of 5%, a Monte Carlo size of 10,000 has been used to calculate simulated critical values and test statistics under investigation.

Table 2 illustrates the results of four time-variant tests having the null hypothesis of no cointegration corresponding to all possible specifications for all countries. It can be observed that the TVPOZA test captures the 100% (perfect cointegration) long-run relationship of consumption function for all specifications corresponding to all countries with a p-value equal to zero.

**Table 2**: Empirical Evaluation of time-varying with Null of No Cointegration Tests.

| | | TVPOZA | | TVPOPU | | TVTECM | | TVPH | |
|---|---|---|---|---|---|---|---|---|---|
| Country | Specification | Test-Value | P-Value | Test-Value | P-Value | Test-Value | P-Value | Test-Value | P-Value |
| Canada | $D^0T^0$ | -390.99 | <0.01 | -3.06 | 0.67 | -150.93 | 0.10 | -6.24 | 0.20 |
| | $D^1T^0$ | -378.01 | <0.01 | -1.20 | 0.16 | -126.43 | 0.05 | -5.69 | 0.01 |
| | $D^1T^1$ | -392.00 | <0.01 | 16.30 | 0.62 | -152.00 | 0.05 | -6.10 | <0.01 |
| Japan | $D^0T^0$ | -141.03 | <0.01 | 34.91 | 0.78 | -85.06 | 0.07 | -5.19 | <0.01 |
| | $D^1T^0$ | -157.90 | <0.01 | 29.23 | 0.89 | -89.19 | 0.05 | -5.80 | <0.01 |
| | $D^1T^1$ | -131.87 | <0.01 | 35.11 | 0.99 | -77.84 | 0.05 | -5.06 | <0.01 |
| South Africa | $D^0T^0$ | -263.12 | <0.01 | 58.02 | 0.38 | -123.42 | 0.07 | -6.28 | 0.03 |
| | $D^1T^0$ | -256.22 | <0.01 | 220.21 | 0.25 | -118.73 | 0.05 | -5.96 | 0.01 |
| | $D^1T^1$ | -251.90 | <0.01 | 310.32 | 0.28 | -113.36 | 0.04 | -5.89 | 0.01 |
| UK | $D^0T^0$ | -246.14 | <0.01 | 104.06 | 0.71 | -134.38 | 0.07 | -4.79 | 0.02 |
| | $D^1T^0$ | -226.86 | <0.01 | 155.62 | 0.44 | -126.21 | 0.05 | -6.25 | <0.01 |
| | $D^1T^1$ | -231.98 | <0.01 | 171.90 | 0.54 | -131.77 | 0.05 | -6.33 | <0.01 |

However, the TVPOPU test is unable to explain the presence of a long-run association with a p-value over 5% at all model specifications for all countries. This indicates no cointegration behaviour between the variables of the consumption function. As a result, this test is unable to perform well as required.

TVTECM test shows the same results of existing cointegration as has been observed for the TVPOZA test at two model specifications except for $D^0T^0$, where the p-value is slightly greater than 5%, for all countries. However, this test was unable to perfectly capture (i.e. 100%) the presence of a long-run relationship. Similarly, the results outlined in Table 1 for the TVPH test also illustrate the presence of long-run association of consumption function for all countries corresponding to all model specifications except for Canada with specification $D^0T^0$ where the p-value is far greater (i.e. 20%) than 5%.

Table 3 explains the results obtained for the test having the null hypothesis of cointegration test (TVLM) corresponding to all model specifications for similar four countries as has been observed previously. According to obtained results, the TVLM test reflecting the existence of the long-run relationship, as the p-value is far greater than the nominal size thus not rejecting the null hypothesis, for the considered consumption function.

**Table 3**: Empirical Evaluation of time-varying with Null Cointegration (TVLM) Test.

| Country | Specification | Test-Value | P-Value |
|---|---|---|---|
| Canada | $D^0T^0$ | 0.05 | 1.00 |
| | $D^1T^0$ | 0.07 | 1.00 |
| | $D^1T^1$ | 0.09 | 1.00 |
| Japan | $D^0T^0$ | 0.40 | 0.93 |
| | $D^1T^0$ | 0.31 | 0.99 |
| | $D^1T^1$ | 0.31 | 0.98 |
| South Africa | $D^0T^0$ | 0.08 | 0.86 |
| | $D^1T^0$ | 0.06 | 0.28 |
| | $D^1T^1$ | 0.04 | 0.09 |
| UK | $D^0T^0$ | 0.10 | 0.62 |
| | $D^1T^0$ | 0.10 | 0.58 |
| | $D^1T^1$ | 0.08 | 0.60 |

Overall results indicate that TVPOZA, TVTECM, TVLM, and TVPH time-varying cointegration tests perform better to show the existence of cointegration for consumption function. However, among these four better-performing tests, the TVPOZA test with 100% attaining the existence of a long-run relationship is identified to be the most powerful test corresponding to all considered model specifications. On the other side, the TVPOPU time-varying test was unable to capture the presence of cointegration is declared as the worst-performing test at all specifications.

## 5 Conclusion

In this research study four modified time-variant cointegration tests, three belong to the null hypothesis of no cointegration while one belongs to the null hypothesis of cointegration, have been compared empirically using consumption function to find the better performing test/tests. Quarterly data from Q1-1960 to Q4-2018 for the United Kingdom, Canada, South Africa, and Japan were taken to calculate test statistics, TVTECM, TVPOZA, TVPH, TVLM, and TVPOPU. All tests, excluding the TVPOPU test, have captured the existence of a long-run relationship among variables present in the consumption function for almost the majority of the model specifications. However, the TVPOZA test with the strength to perfectly capture the presence of long-run association in all specifications in the consumption function has been identified as the most powerful test as compared to the rest. While the TVPOPU test with the inability to capture the cointegration pattern for all considered model specifications in the consumption function is recognized as the worst performer test.

From this study, when dealing with real data it is recommended to apply the TVPOZA time-varying cointegration test and avoid using the TVPOPU test.

## 6 Availability of Data and Material

Data can be made available by contacting the corresponding authors.

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