COINTEGRATION MODELS OF THE BRICS ECONOMIES

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ABSTRACT

This research investigates whether financial markets of BRICS and developed countries provide benefits from international diversification. This problem has been covered by a huge number of researchers, which works has been analyzed for this work, but it is interesting for investors to know, whether diversification between this countries is still beneficial or not. Japan, USA, Great Britain and Australia were taken as developed countries. According to the strategy of the research, it consists of the Cointegration models. The result of this research paper indicated that particularly nowadays situations is that international diversification is profitable the conclusion is based on empirical proofs that pointed that nowadays linkages between BRICS and developed countries are rather low, what is good for the investor to pay attention to.

Keywords: BRICS, linkages, international diversification, investment management.

Metodology of Cointegration

The main idea of Cointegration is the Johansen method, which allows to test whether cointegration exists between any of our time series data, or not. The Johansen approach enables to identify the maximum number of co-integration vectors, which exist between a set of a variables. This estimation method for co-integrated variables using the maximum likelihood method was presented by Johansen (1988). Johansen test also allows testing a number of co-integrated vectors. In addition to that, the base for this test is estimating a VaR model in differences, which can be described using Johansen prism:

$$\Delta x_t = \mu + \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + _{\dots} + \Gamma_{p-1} \Delta X_{t-p-1} + \prod X_{t-p} + BZ_{t+u_t}$$

Where:

- (M×1) matrix of I(1) variables - X

- (S×1) matrix of I(0) variables - Z
- (M×M) matrixes of an unknown parameters - The Γ_j and $\prod$,
- (M×S) matrix of the unknown parameter - B,
- number of variables in X - M,
- maximum lag in the equation (VaR model) - p

According to the situation when $\prod$ has a zero rank, than non-stationary linear combinations can be identified, meaning that the variables in X_t are not co-integrated. In contrast, any time $\prod$ has a rank, a liner combination of the variables in X_t are co-integrated. According to this research, the 3rd case will be used because of it is the one should be used for trending series and all the graphs of the log series provide information about up-trend or down-trend, in this case this method is the most appropriate for usage. Additionally, included number of lags within the model will be decided by minimising the Akaike's error criterion.

In case of co-integration tests' results will provide some information about co-integration relationships, than ECM can be calculated . This, model is restricted VaR created for use with non-stationary series, which are co-integrated.

An error correction model is a dynamical system with the characteristics that the deviation of the current state from its long-run relationship will be fed into its short-run dynamics. Basically this model is not correcting other model's error. This Model is related to a category of multiple time-series models that directly estimate the speed at which a dependent variable – Y – returns to equilibrium after a change in independent variable – X. This model is rather useful for estimation both short-term and long-term effects of one time series on another. This method will be applied to co-integrated data under study.

According to the calculation process will be applied, the following formula will be as a start point:

$$Y_t = KX_t;$$

This is a simple proportional, long-run equilibrium relationship between two variables. Where **Y** is a dependent and **X** is an independent;

The relationship above in a long-term form can be written as

$$y_t = k + x_t;$$

General dynamic relationships between *y* and *x* could be written as:

$$y_t = \beta_0 + \beta_1 x_t + \beta_2 x_{t-1} \alpha_1 y_{t-1} + u_t;$$

This specification allows for a wide variety of dynamic patterns in data, by including lagged values of both x and y.

To assess under what considerations is the generic dynamic equation consistent with the long-run equilibrium relationship the following step is to zero out could cause divergence from equilibrium factors, in this way the following formula we've got:

$$y* = \beta_0 + \beta_1 x^* + \beta_2 x^* + a_1 y^*$$

$$(1 - a_1)\ y* = \beta_0 + (\beta_1 + \beta_2) x^*$$

$$y* = \frac{\beta_0}{1 - a_1} + \frac{\beta_1 + \beta_2}{1 - a_1} x^*$$

In the situation, where the first-step equation corresponds with the above we have the following:

$$\frac{\beta_0}{1 - a_1} = k$$

$$\frac{\beta_1 + \beta_2}{1 - a_1} = 1$$

Suppose that in this case the second above relationship lead to $\beta_1 + \beta_2 = 1 - a_1$, in this way let γ denote the common value of these two terms. Then β_2 can be written as $\gamma - \beta_1$ and a_1 can be written as $1 - a_1$. In this way equation becomes:

$$y_t = \beta_0 + \beta_1 x_t + (\gamma - \beta_1) x_{t-1} + (1 - \gamma) \gamma_{t-1} + u_t;$$

$$y_t = \beta_0 + \beta_1 x_t - \beta_1 x_{t-1} + \gamma x_{t-1} - \gamma y_{t-1} + y_{t-1} + u_t;$$

$$y_t - y_{t-1} = \beta_0 + \beta_1(x_t - x_{t-1}) + \gamma(x_{t-1} - y_{t-1}) + u_t;$$

In the final step:

$$\Delta y_t = \beta_0 + \beta_1 \Delta x_t + \gamma(x_{t-1} - y_{t-1}) + u_t;$$

Where $\Delta x_t = x_t x_{t-1}.$ This means the characteristic "Error Correction" specification.*

*Where the change in one variable is related to the change in another variable, the same as the gap between the variables in the previous period.

BRICS Models

According to the Augmented Dickey-Fuller (ADF) test indicates, that all under study series contained a unit root, in this way we can use co-integration models as a next step. The analysis will be done through comparing all countries each other: Brazil, Russia, India, China, South Africa, USA, Australia, Japan.

According to the results of applying Johansen test eigenvalue and trace statistics are reported. If maximal eigenvalue and trace statistics contradict each other, precedent will be given to the trace test because of Lutkepohl et al (2001) study provided that a recent Monte-Carlo compared the trace test and eigenvalue tests results, simulate and based on their simulation they had a preference for the trace test. Both tests indicate no co-integration between Brazil – USA and Brazil – Australia, but for the last co-integration pair of Brazil and Japan, Trace test indicated two co-integrating vectors in this model. The null hypothesis can be rejected only in this pair at 95% significant level, because first two (Brazil – USA, Brazil Australia) have tests results higher than 5%. These results mean that Brazil – USA, Brazil – Australia pairs have no stochastic trend, i.e. there are no long-run relationships between countries stocks in each pair. In contrast to them, Brazil and Japan stock markets have a stochastic trend. The integration between these markets will be looked at in further detail applying a time-varying parameter. The following tables provide same tests results, three pairs were analysed: Russia – USA, Russia – Australia, Russia – Japan.

Both tests indicate no co-integration between Russia – USA and Russia – Australia**,** but for the last co-integration pair of Russia and Japan, both tests indicated two co-integrating vectors. The null hypothesis can be rejected only in this pair at 95% significant level, because first two (Russia – USA, Russia Australia) have tests results higher than 5%. These results mean that Russia – USA, Russia – Australia pairs have no stochastic trend, i.e. there are no long-run relationships between countries stocks in each pair. In contrast to them, Russia and Japan stock markets have a stochastic trend. The integration between these markets, same as Brazil and Japan pair, will be looked at in further detail applying a time-varying parameter. The following three tables provide information about India – USA; India – Australia, India – Japan tests results**.**

Both tests indicate there is no co-integration between India – USA India – Australia pair has one co-integrating vector, indicated by Trace test. India – Japan pair has two co-integrating vectors, indicated by Trace test. The null hypothesis cannot be rejected in first two pair (India – USA). These results mean that India – Australia, India - Japan pairs have stochastic trends (each pairs' markets between each other), i.e. there are long-run relationships between countries stocks in this pair.

Both tests indicate there is no co-integration between China – USA, China – Australia, China – Japan. The null hypothesis cannot be rejected in these pairs. These results mean that China – USA, China – Australia, China - Japan pairs have stochastic trends, i.e. there are no long-run relationships between countries stocks in each pairs.

Both tests indicate no co-integration between South Africa – USA and South Africa – Australia, but for the last co-integration pair of South Africa and Japan, Trace test indicated two co-integrating vectors. The null hypothesis can be rejected only in this pair at 95% significant level, because first two (South Africa – USA, South Africa - Australia) have tests results higher than 5%. These results mean that South Africa – USA, South Africa – Australia pairs have no stochastic trend, i.e. there are no long-run relationships between countries stocks in each pair. In contrast to them, South Africa and Japan stock markets have a stochastic trend. The integration between these markets will be looked at in further detail applying a time-varying parameter.

Moreover, Johansen test was applied for BRICS countries pairs

- Brazil – Russia; Brazil – India; Brazil – China; Brazil – South Africa;
- Russia – Brazil; Russia – India; Russia – China; Russia – South Africa;

- China – Russia; China – India; China – Brazil; China – South Africa;
- South Africa – Russia; South Africa – India; South Africa – China; Brazil – South Africa;

Finally, the Johansen test indicates existence of a long-run relationship between the stock markets under study. However, long-run relationships among the various stock douse not 100% prove that that international diversification is no longer beneficial. Co-integration analysis is useful to get an adequate understanding of whether a long-run relationship existence for a given time period exist or not, but a gradual move towards or away from a closer relationship could not be indicated. Therefore in the following sections a time-varying parameter model will be estimated to provide information about if the stock markets have become more closely linked over the given time period.

The factor of co-integration vectors foundations has several implications. The existence of a higher degree of correlation between two variables may be purely than a causal relationship because of mathematical reasons. Nevertheless, these models have co-integrating vectors, in this way error correction model calculation is possible for them. In conclusion, indication of a co-integration test is whether series move together in equilibrium relationship

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