Dynamic Behavior of Country Risk in the BRICS Countries: from the Perspective of Time-varying Correlation

Yuying Yang
Graduate University of Chinese Academy of Sciences
Institute of Policy and Management, CAS,
Beijing, China
E-mail: yangyuying876@gmail.com

Xiaoqian Zhu
Graduate University of Chinese Academy of Sciences
Institute of Policy and Management, CAS,
Beijing, China
E-mail: xiaoqian@mail.ustc.edu.cn

Xiaolci Sun
Institute of Policy and Management, CAS,
Beijing, China
E-mail: xlsun@casipm.ac.cn

Jianping Li
Institute of Policy and Management, CAS,
Beijing, China
E-mail: ljp@casipm.ac.cn

Dengsheng Wu
Institute of Policy and Management, CAS,
Beijing, China
E-mail: wds@casipm.ac.cn

Abstract—Country risk is a quite important factor for international investment. Many institutions and researchers try to assess country risk by using numerous indicators and various evaluation models. This paper investigates the dynamic behavior of country risk in order to offer more detailed information of country risk to investors. First, country beta is taken as the proxy of country risk. Second, dynamic conditional correlation (DCC) model is used to calculate the time-varying beta. Considering the fast development of Brazil, Russia, India, China and South Africa (BRICS), these five BRICS countries are selected as empirical sample, and the results show that the five countries index return dynamic volatilities fluctuate strongly in late 2008 which can be ascribed to the finance crisis. Besides, the dynamic correlation coefficients of BRICS with the world stock index yields show a rising trend and their correlation coefficients are positive, especially, after the finance crisis in 2008, BRICS correlation coefficients against the world are getting closer, this means that BRICS are playing a more important role in the world in some degree. Our research also finds that BRICS countries betas are unstable and above 1 usually.

Keywords- Country Beta; Country Risk; Dynamic Behavior; DCC-GARCH model; Finance Crisis

I. INTRODUCTION

Country risk refers to the national risk when investing in a foreign country, and may change the business environment. Given that country risk adversely affects operating profits or the value of assets in a specific country, Country risk has received a great deal of attention in many fields, such as overseas investment, energy trading [1, 2, 3, 4]. In order to offer country risk information, many international agencies, such as institutional Investor, Standard & Poor’s Rating Group, and the PRS Group, devote them to offering country risk ratings by using various methods, and usually base on low frequency data such as annual data or monthly data. Sometimes, low-frequency data ratings are unable to entirely meet investor short-term demand for more detailed information on country risk. Therefore, in this paper, we try to propose a framework to model and analyze the dynamics of country risk based on weekly data.

Considering these rating agencies seldom completely make their rating systems public, many studies focus on the country risk assessment by using numerous indicators and various evaluation models in a multi-attribute framework [5, 6, 7]. However, it is proved that these approaches mainly based on multiple variables are time consuming and difficult in index selection. Out of the need to overcome the drawbacks of the multi-variable evaluation approach, a lot of researchers try to address country risk from a portfolio investment perspective based on the capital asset pricing model and proxy for country risk by using beta [6, 8, 9, 10, 11, 13]. A proverb, "Do not put all eggs in one basket", illustrates Modern Portfolio Theory that diversified portfolio is used to defuse the investment risk. From a portfolio investment perspective, country selection is also a good way to diversify risk and increase gains. Given that all the countries in the world are a portfolio and each country can be seen as an asset, then the country risk is like the beta in CAPM which determines the expected return, so we can proxy for country risk by using beta to examine the sensitivity of each country relative to global change.
Given that the beta is one of the important risk factors for the international investors, it is crucial to understand its dynamic behaviors. The studies on beta and country risk could be classified into three kinds: the first focuses on the relationship between beta and country risk [14]; the second investigates the factors influencing beta [7, 8]; the last studies on the time-varying beta and find the best model to estimate beta [8, 11, 13]. Instructively, beta has been proved to be time-varying in both developed countries and emerging market countries [8, 11].

In this paper we use time-varying beta as a proxy for BRICS countries risk, which is defined as country beta in this paper. Given that country beta is calculated based on the relationship between one country and the global economy, the correlation should be considered when modeling country beta. GARCH-based models often generate the lowest forecast error for dynamic correlation estimation [11, 12]. Specially, DCC-GARCH model is a useful tool put forward by Engle (2002) for dynamic correlation estimation [15].

This paper attempts to investigate the dynamic country beta of BRICS during the period 2006 to 2010, from the perspective of time-varying correlation by using DCC-GARCH method. During the sample period, the financial crisis caused by U.S. subprime loans had a great impact on the global economy. For international investors, BRICS (Brazil, Russia, India, China, South Africa) countries are the preferred selection for the high investment return. It is also of particular importance for the international investors to provide more detailed country risk information about its dynamic behaviors, especially when U.S. subprime crisis influenced.

The rest of this article is organized as follows: Section II describes country beta and the DCC-GARCH model in brief. In section III, the data used in the model and the empirical results are presented. Finally, Section IV concludes.

II. MODEL SPECIFICATIONS

A. Country Beta based on CAPM

Following Sharp (1964) [16] and Lintner (1965) [17] unconditional beta for any asset is estimated by the standard market model regression:

\[ E(r_i) = r_f + \beta_{im}(E(r_m) - r_f) \]

Where \( E(r_i) \) is expected return on asset \( i \); \( E(r_m) \) is the portfolio expected return and \( r_f \) is risk-free return. The intercept and slope vectors are assumed constant over time, \( \beta_{im} = \frac{\text{Cov}(r_i, r_m)}{\text{Var}(r_m)} \) reflects the relative risk of asset \( i \), measuring the sensitivity of the return on asset \( i \) to the return on portfolio. If \( \beta_i > 1 \) or \( \beta_i < 1 \), that mean asset \( i \) has greater or less risk than that of the overall portfolio. Furthermore, from an international investor point of view, beta measures the contribution of that asset to the total risk of portfolio.

Given that all the countries in the world are a portfolio and each country can be seen as an asset, then the country risk is like the beta in CAPM which determines the expected return, so we can represent country risk by using beta to examine the sensitivity of each country relative to global change and this beta can be called country beta.

B. Dynamic Country Beta based on DCC-GARCH

In this section, we present the DCC (1, 1)-GARCH (1, 1) model that we then use to estimate time-varying betas for BRICS. The model is put forward by Engle (2002) [15] to estimated time-varying correlations by avoiding the problems of relying solely on unconditional variance-covariance matrix [8]. The model can be written as:

\[ r_i = \Omega_{i,t}^{-1}N(0, D_i, D_i) \]

\[ h_{it} = \omega_i + \alpha_i r_{it-1}^2 + \beta_i h_{it-1}, \quad i = 1, A, k \]

\[ \varepsilon_i = D_i^{-1} r_i \]

\[ Q_t = (1 - a - b)\Omega + ae_{i,t-1}e_{i,t-1}' + bQ_{t-1} \]

\[ R_t = \text{diag}(Q_t)^{1/2}Q_t\text{diag}(Q_t)^{1/2} \]

With \( e_{i,t} = [e_{i,1}, \ldots, e_{i,k}] \) as the k-dimensional vector of zero mean excess risky return(here k equal 6 for 5 countries and world market), \( \Omega = \text{diag}([\tilde{h}_{1,t}, \ldots, \tilde{h}_{k,t}]) \), which represents a \( k \times k \) diagonal matrix of conditional standard deviations, \( h_{it} \) as the \( k \times k \) time-varying correlation matrix, \( Q_t \) is the positive definite matrix and \( a \geq 0, b > 0, a + b < 1 \), \( \tilde{Q} = E(\varepsilon e') \) as the unconditional covariance matrix of standardized variables.

The processor to obtain time-varying beta can be divided to three steps:

1. **Step 1:** use univariate GARCH(1,1) model(Eq.(3)) to get each country time-varying deviations and world market time-varying deviations they are time-varying volatilities exhibited as Figure 2, then translate the return vector into time-varying standard disturbance vector through Eq.(4);
2. **Step 2:** use DCC(1,1) model (Eq.(5),(6)) to calculate each country time-varying correlation with world market(benchmark world market index) based on the result achieved in the first step;
3. **Step 3:** every country time-varying beta against the benchmark world index can be obtained by the follow equation [8]:

\[ \text{beta}_i = \frac{\text{Cov}(r_{i,t}, r_{m,t})}{\text{Var}(r_{m,t})} = \frac{\text{Cov}(r_{i,t}, \sqrt{h_{i,t}})}{\sqrt{\text{Var}(r_{m,t})}} = \frac{\sqrt{h_{i,t}}}{\text{Var}(r_{m,t})} \]

III. EMPIRICAL RESULTS

In this section, we begin by describing the stock data for BRICS countries and the benchmark-world index. The DCC-GARCH model described above is then applied to each of the five countries and the time-varying volatilities and correlations are used to calculate time-varying betas.

**A. Data**

The country data used in this study are sourced from the Morgan and Stanley Capital International (MSCI) database.
These US dollar value weighted indices are gathered at a weekly frequency from January 4, 1995 to April 21, 2010 giving a total of 799*6 observations. The countries included in this study are Brazil, Russia, India, China, and South Africa. The MSCI World Index is chosen as the representative market portfolio against which country risk are assessed. The continuously compounded percentage return of each index series is calculated as the log of the price differences (\( r_{it} = \frac{100 \times \ln(P_{it}/P_{i,t-1})}{1} \)). The log returns for each of the six markets are shown in Figure 1. The figure shows signs of significant volatility clustering, indicative of heteroscedasticity. Figure 1 shows that the stock returns in BRICS vary quite different. The maximal return in Russia is about 50%, while the return in South Africa is only about 10%. The maximal return in Brazil, India and China are about 25%, 25% and 20%, separately. It is easy to find that the returns in BRICS and the world change intensely in the year 1997 and 2008, which can be explained by the Asian financial crisis and global financial crisis in 2008.

\[ r_{it} = \frac{100 \times \ln(P_{it}/P_{i,t-1})}{1} \]

Figure 1. The price index return

**B. The parameter specification**

<table>
<thead>
<tr>
<th>Country</th>
<th>GARCH parameters</th>
<th>DCC parameters</th>
<th>LogL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \omega_i )</td>
<td>( \alpha_i )</td>
<td>( \beta_i )</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.96(0.47)**</td>
<td>0.17(0.05)**</td>
<td>0.79 (0.06)**</td>
</tr>
<tr>
<td>Russian</td>
<td>1.23(0.66)</td>
<td>0.14(0.04)**</td>
<td>0.84 (0.04)**</td>
</tr>
<tr>
<td>India</td>
<td>0.73(0.30)**</td>
<td>0.14(0.04)**</td>
<td>0.82 (0.05)**</td>
</tr>
<tr>
<td>China</td>
<td>0.44(0.23)**</td>
<td>0.15(0.03)**</td>
<td>0.85 (0.03)**</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.45(0.29)</td>
<td>0.08(0.02)**</td>
<td>0.87 (0.04)**</td>
</tr>
</tbody>
</table>
Notes: values in parenthesis are standard deviations. ** denotes significant at 0.05 level.

Table I displays the results of DCC (1, 1)-GARCH (1, 1) for the whole sample. The estimated DCC parameters, a and b, are both statistically significant, suggesting that BRICS betas fluctuate over time and our findings are consistent with the literature [8, 15].

C. Time-varying country beta

The time-varying volatilities (deviations) of the five countries are presented in Figure 2. Five countries experienced a relatively stable volatilities pattern across the sample, except for a spike during the global financial crisis in 2008. Russia is the most severely affected country during October 2008-April 2009. Although five countries are affected, volatilities gradually recover to a steady state within a very short time. Specially, Russia is affected most severely, while South Africa seem not be affected by the global financial crisis in 2008.

The dynamic correlations patterns between each of the five countries and the world are presented in Figure 3. All five countries experienced large changes in correlation against the world during the period 2006-2010. However, Brazil and Russia are two countries that fluctuate mostly and have a minimum value about 0.4 in August 2008. During the period January 2006-July 2008, Brazil country beta is the largest among the five countries and its value is above 0.6. The dynamic correlations value and trend of India and China are similar and fluctuate in small between 0.5–0.6. Russia dynamic correlation fluctuate bigger than any other four countries, but its value is the minimal of the five countries. In August 2008, the dynamic correlations of countries that flocculate mostly have a drop and reach a minimal about 0.4, while the correlations of other three countries keep stable. After October 2008, the BRICS countries correlations against the world are getting closer. During the overall period January 2006-April 2010, India, China and South Africa have the similar pattern and their correlations against the world show a linear upward trend, this may be explained by the advance of globalization. In additional, before 2008 the five countries dynamic correlation coefficients against the world are quite different and Brazil dynamic correlation coefficient is the largest while Russia’s is the minimal, but after 2008, the five countries correlation coefficients are very close and their values are approximately 0.8. This means that BRICS are playing a more important role in the world in some degree.

Finally, time-varying betas are computed, using the time-varying volatilities and time-varying correlations through Eq. (7). Time-varying country betas are presented in Figure 4. It is clear that the country risk measured in term of country betas vary considerably over time and are above 1 most time. Beta reflects the relative risk of country i, measuring the sensitivity of the return on country i to the return on world portfolio, if beta is greater than 1, that means the country systemic risk is higher than the average systematic risk of the whole world and that this country is more sensitive to relative changes in the whole world. Also, the patterns differ among the five countries; Russia country risk fluctuates mostly and South Africa country risk has the minimal country risk on average during 2006-2010. Russia country beta is always the largest among the five countries and shows an upward trend, while China, India and Brazil
country betas show a downward trend. Those results show that the BRICS are different despite the fact that they are the same level of development and have similar structural features. But this does not mean they take similar measures when facing the similar situation. An investor can gain great return in the Russia but he also have to face particularly high systematic risk than in South Africa.

Table II reports the summary statistics for each country dynamic country beta. South Africa country beta in mean is the smallest of the five countries and fluctuates in small, while all other four countries betas in mean are above 1. The maximum beta of Russia reach 2.727 and China is 2.633, but the smallest of the five countries market are getting closer and closer with the world during the period 2006-2010 demonstrate that the BRICS are different despite the fact that they are the five countries market are getting closer and closer with the world during the period 2006-2010.

The five countries are all influenced by the financial crisis of their dynamic volatility, and Russia is mostly severely affected. All five countries time-varying correlations against the world during the period 2006-2010 demonstrate that the five countries market are getting closer and closer with the world market, showing a highly positive correlation with the world. Time-varying country betas vary considerably over time and Russia country beta is always the largest among the five countries and shows an upward trend, while China, India and Brazil country betas show a downward trend. South Africa’s have the minimal country risk on average during 2006-2010.

IV. CONCLUSIONS

Country risk assessment is vital for international investment, which recently has increasingly focused on Brazil, Russia, India, China and South Africa. The primary focus of this paper is modeling country risk in BRICS using time-varying beta based on CAPM. Our results show that these five countries are all influenced by the financial crisis from their dynamic volatility, and Russia is mostly severely affected. All five countries time-varying correlations against the world during the period 2006-2010 demonstrate that the five countries market are getting closer and closer with the world market, showing a highly positive correlation with the world. Time-varying country betas vary considerably over time and Russia country beta is always the largest among the five countries and shows an upward trend, while China, India and Brazil country betas show a downward trend. South Africa’s have the minimal country risk on average during 2006-2010.

ACKNOWLEDGMENT

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REFERENCES


TABLE II. THE STATISTICS OF TIME VARYING COUNTRY BETA (2006-2010)

<table>
<thead>
<tr>
<th></th>
<th>Brazil</th>
<th>Russia</th>
<th>India</th>
<th>China</th>
<th>South Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.341</td>
<td>1.507</td>
<td>1.200</td>
<td>1.319</td>
<td>0.926</td>
</tr>
<tr>
<td>Std.Dev.</td>
<td>0.295</td>
<td>0.423</td>
<td>0.276</td>
<td>0.281</td>
<td>0.218</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.350</td>
<td>-0.494</td>
<td>0.125</td>
<td>2.923</td>
<td>-0.729</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.149</td>
<td>0.476</td>
<td>0.470</td>
<td>1.350</td>
<td>0.325</td>
</tr>
<tr>
<td>Min</td>
<td>0.627</td>
<td>0.801</td>
<td>0.671</td>
<td>0.769</td>
<td>0.470</td>
</tr>
<tr>
<td>Max</td>
<td>2.116</td>
<td>2.727</td>
<td>1.975</td>
<td>2.633</td>
<td>1.379</td>
</tr>
<tr>
<td>Observations</td>
<td>225</td>
<td>225</td>
<td>225</td>
<td>225</td>
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