INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ECONOMICS & MANAGEMENT SCIENCES

OPEN ACCESS JOURNAL

Vol 12, Issue 1, (2023) E-ISSN: 2226-3624

Stock Return, Financial Stability and Green GDP in China: Evidence from NARDL and Quantile Regression

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To Link this Article: http://dx.doi.org/10.6007/IJAREMS/v12-i1/16431 DOI:10.6007/IJAREMS/v12-i1/16431

Published Online: 18 March 2023

Abstract

This paper evaluates the effect of financial stability on stock return – green GDP and GDP relationships. The ARDL and quantile regression analysis are applied for this objective and the datasets are covering from 2002:Q1 to 2018:Q4. The empirical results reveal that financial stability has a positive and significant stimulating effect on the stock return-green GDP nexus. In other words, similar to institutional quality, financial stability provides an adequate ground to the stock return to have positive impact on green GDP. The more stable financial system in the country leads to investments and stock returns to be placed on activities that conserve the environment and hence increase in green GDP. Thus, the stability of the financial system plays a crucial role in ensuring the well-functioning of stock market and hence, promote green GDP. While the results for GDP indicated that stock return has insignificant impact on GDP in the direct or even the interaction effect with financial stability.

Keywords: Green GDP, Stock Return, Financial Stability, China, Quantile Regression.

Introduction

In the past ten years, the scale of China's stock market has grown by 238.9%, ranking second in the world in terms of market size, with more than 200 million stock market investors. The market is beginning to recognize the impact of carbon emissions risk on company value and stock returns, but the research of relationship between stock return and exhaust pollutant emissions in China still have not found.

The stock market-Green GDP nexus is not well established in the past studies. However, studies have paid attention to stock market and green GDP's components, such us the impact of stock market on carbon dioxide damage, net forest depletion, mineral depletion, and water depletion (Vaghefi et al., 2015; Zhang et al., 2019; Zhang, 2011; Ullha & Ozturk, 2020). Therefore, stock market could affect green GDP via its effects on environment depletion, which at the end affects green GDP.

Stock market-environment link can be explained in different ways. For instance, evidences indicate that stock market punishes firms with harm performance on environmental and

reward those that do well environmentally (Salinger, 1992; Krueger, 2015; Klassen & McLaughlin, 1996; Ferrell et al., 2016). In addition, firms with low emissions especially in carbon-intensive industries, benefit from lower costs of equity (Trinks et al., 2017). This indicates that firms with environment friendly outcomes would have lower equity costs compared with firms damage the environment.
Furthermore, stock market plays a pivotal role in which allocates capital to clean energy projects. For instance, stock market increases the investing amount of fund in environment friendly projects, also, increases both the liquidity and the diversification for achieving higher risk-adjusted returns from energy investments (Paramati et al., 2016). Therefore, increasing of stock market development leads to clean energy production through the better use of new technologies, as well as energy efficiency which leads to significantly reduce of CO2 emissions, and thus higher green GDP.
Stock markets facilitate the allocation of investment towards more carbon-efficient sectors via the adoption of clean technologies. It is evidenced that deeper stock markets are associated with more green innovation. In other words, The stock market provides companies with additional liquidity by listing their stocks on the stock exchange, which provides alternative investment opportunities for domestic and international investors (Paramati et al., 2016).
Figure 1.6 shows the trend of green GDP and stock return (in log form) in China since 1992. The figure illustrates that stock return and green GDP show a similar pattern from 1992 to 2017 with a slight difference after 2005, which may occur due to the financial crises that affect stock return in China. However, the gap between stock return and green GDP is enormous because of the high green growth of China compare with stock return development. Stock return has fluctuation trend compared with GDP.

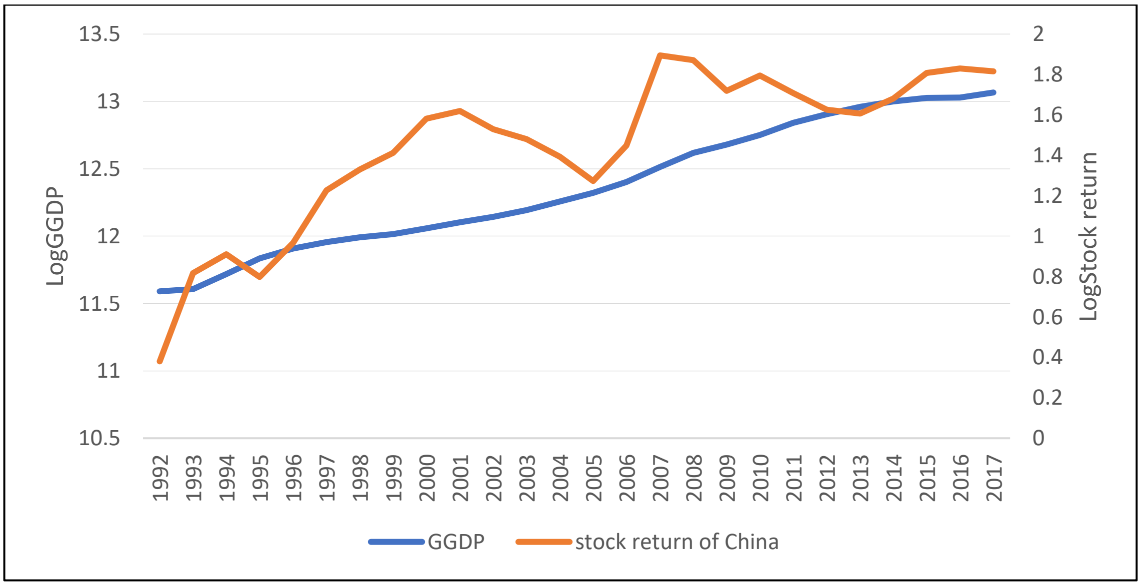

Figure 1: Stock return and green GDP in China
(Source: Author calculation based on World bank.)

Financial stability is a factor that moderates environmental degradation; however, its direct and indirect role on green GDP is a missing link in the existing literature. For instance, the role of financial stability is directly linked with CO2 emissions (Richard, 2010; Nasreen et al., 2017). Additionally, these studies have concerned mostly on one aspect of environment which is CO2 emissions, where, less attention has been paid to green GDP. It is well documented that; financial stability improves environment quality and it plays essential role in allocating financial resources to productive activities. Therefore, the issue arises is whether financial stability would channel stock returns into friendly environment activities in China.

Literature Review

A recent literature such as Hismendi et al (2021) on the role of stock market on economic growth for Indonesia, the study applied VECM method and causality tests. Their findings indicate that the agricultural, financial, industrial, and mining sectors have a balanced relationship with economic growth in the short term. However, in the long run, a balanced relationship exists between agricultural, financial, industrial, and mining sector economic growth and overall economic growth. Another related study by Ibrahim et al (2021) found that there is existence of long run functional relationship between stock market capitalization, stock market turnover ratio, number of listed companies and total value traded on GDP. A 1% increase in the market capitalization ratio leads to approximately 13.9 percent decrease in GDP.

The vital cause of the financial crisis is the unstable financial system, and financial crises have distress for economic growth (Manu et al., 2011). Kindleberger (1978); Minsky (1991), prove a light on the financial instability and its negative influence on economic growth. Kindleberger (1978) stressed the importance of trust and confidence in institutions and pointed out that the loss of confidence could lead to disintermediation and institutional closures and subsequently falling in the investment (Dhal et al., 2011).

Sundarajan (1991) defines the financial crisis as when the liabilities of a large group of financial institutions exceed the market value of the assets, and shifting in a portfolio leads to the collapse of the government's financial institution and intervention. Recent literature has emphasised the importance of financial stability on economic growth. Eichengreen and Arteta (2000) investigated 75 emerging market economies over the period 1975–1997. The study attributed the banking crisis in emerging countries to rapid domestic credit growth and large bank liabilities. Similarly, Borio and Lowe (2002) used the data for 34 countries from 1960 to 1999. They confirmed that combining rapid credit growth with a substantial increase in asset prices increase the probability of financial instability. Caldero'n et al (2003) found that the higher degree of policy credibility of the microeconomic policy and mature institutions allows emerging countries to pursue countercyclical fiscal and monetary policy and leads to a better investment environment and rapid growth. Schinasi (2004) asserted that a stable financial system contributes to better economic performance while an unstable financial system disturbs economic performance.

A recent study by Creel et al (2015) linked financial stability and economic performance in the European Union. They found that financial instability affects economic performance components, such as investment, consumption, and disposable income. Moreover, financial instability hurts economic growth. Cheang (2004) is of the view that the cost of financial instability is more evident than the benefit of financial stability to an economy. He studied Macao's financial system and its effect on economic growth and concluded that although Macao has a sound financial system; however, the relationship between financial stability and economic growth is not apparent.

Some studies have focused on the banking system and its impact on economic growth. The study by Jokipii & Monnin (2013) on the relationship between the stability of the banking sector and the real economy shows the positive relationship between the stability of the banking sector and real output growth. and inflation. However, the study was conducted for periods of instability rather than stable periods. Similarly, Fernández et al (2016) examine the impact of bank stability on the volatility of industrial value-added and confirmed that bank instability reduces the volatility of value-added for industries in countries with developed financial and institutional systems.

Another study by Jayakumar et al (2018) estimates the interaction between banking competition, banking stability, and European countries' economic growth. They find banking stability and banking competition both significantly drive the long-run economic growth. Dhal et al (2011) empirically assessed the linkage of India's financial stability, economic growth, and inflation. They used vector auto-regression (VAR) model and augmented their model with output, inflation and interest rates and a banking sector stability index. Their study revealed that financial stability and macroeconomic indicators have a significant bidirectional Granger causal relationship. Sotiropoulou et al (2019) utilised dynamic panel data techniques to explore the impact of financial development and stability on economic growth. Their result shows the negative effect of banking system development on economic growth. Moreover, the allocation of private credit and market liquidity negatively affects economic growth.

Relatively recent literature attempted to probe the impact of financial instability on the environment. For example, Dasgupta et al (2001) pointed out that the capital market in developing countries reacts to environmental events, and countries with an efficient financial market enjoy a cleaner environment. Tamazian et al (2009) estimated the relationship between economic development, financial development and environmental quality using panel data from 1992 to 2004. The study finds a strong determinant of environmental quality for the country with a developed economy and finance.

In response to climate change, renewable energy demand and generation become essential for the government and companies in China (Cong, 2013). Cong & Shen (2013) linked energy price shocks, financial market stability, and GDP and found the long cointegration among them. They emphasized that investors should pay increased attention in the long run of energy on the financial market. Richard (2010) emphasized the capital markets as a vital tool in providing firms with an incentive that improves environmental records and increases equity shares' value. He finds that financial stability helps in the financing of environmentally friendly projects and indeed benefits the environment.

Brussels (2010) noted that the financial crisis reduced carbon emissions in some European countries and did not find the financial crisis's determinantal impact on the environment. Similarly, Enkvist et al (2010) reported a moderate impact of the global crisis on carbon emissions. More recently, Shahbaz (2013) studied the relationship between financial instability and environmental degradation in Pakistan using ARDL bounds tests. She empirically showed the existence of a long-term relationship between financial instability and ecological degradation. Similarly, Baloch et al (2018) tried from 1971 to 2016 to combine financial instability and environmental quality in the Saudi Arabian economy. They used the ARDL (Autoregressive Distributed Lag) model, estimated the long-term dynamic effects, and claimed that financial instability does not significantly impact CO2 emissions. Finally, Nasreen et al (2017) stressed the limitation of studies linking financial instability, energy consumption, and environmental quality. They used the ARDL bond test cointegration model. They showed that enhance economic growth leads to more industrial pollution and environmental degradation. Safi et al (2021) examined the effects of financial instability on consumption-based carbon emissions in the presence of international trade, technological innovation, and economic growth in Emerging Seven (E-7) countries from 1995-2018. The short- and long-run results confirm the relationship between consumption-based carbon emissions, financial instability, imports, exports, technological innovation, and economic growth.

Methodology

Model Specification

This study adopts the Song et al (2019) model with some modifications to achieve the objective three. The following Eq (1) and Eq (2) stated below are the baseline specification of the subsequent empirical analysis of the interaction effect of stock return and financial stability on green GDP and GDP, respectively. The main interest variables are stock return (STOCKR) and financial stability (FINSTA) and also include other control variables. The model can be written as:

$$\boldsymbol{GGDP_t = \alpha + \beta_1 STOCKR_t + \beta_2 FINSTA_t + \beta_3 (STOCKR * FINSTA) + \beta_4 HC_t + \beta_5 INV_t + \beta_6 POPG_t + \beta_8 TRAD + \varepsilon_t} \qquad \text{Eq(1)}$$

$$\boldsymbol{GDP_t = \alpha + \beta_1 STOCKR_t + \beta_2 FINSTA_t + \beta_3 (STOCKR * FINSTA) + \beta_4 HC_t + \beta_5 INV_t + \beta_6 POPG_t + \beta_8 TRAD + \varepsilon_t} \qquad \text{Eq(2)}$$

Where GGDP is green GDP, GDP is real GDP, FINSTA is financial stability, HC is human capital, INV is investment, POPG is population growth, TRAD is trade openness, and $\boldsymbol{\varepsilon_t}$ is the error terms. Financial stability (FINSTA) is expected to promote green GDP and GDP. Therefore, $\boldsymbol{\beta_2}$ is expected to have positive sign, however, the coefficient may differ and we expect GDP to be higher compare with green GDP. A study of Pošta et al (2022) found that financial stability has a positive and significant effect on growth on Eurasian Economic Union.

This objective includes an interaction term between stock return and financial stability. As stated in the previous subsection, there is a common issue along with the interaction term between the variables. The problem of multicollinearity occurs between the interaction and its variables included in the interaction term. Therefore, to avoid this issue, this study uses the orthogonalization method. To do so, we regress the interaction term (ln STOCKR*ln FINSTA) on ln STOCKR and ln INS variables, and then we replace the interaction term with the residuals collected from the regression (Burill, 2007).

Estimation Methods

Stationary Tests

Two very important tests for stationary are Augmented Dickey Fuller (ADF) test and Philip Perron (PP) test. The ADF test is used to check the stationary of the variables and used for order of integration of the variables. This test uses extra lagged of the time series data to get rid of the autocorrelation in the residuals, and the lag length is determined by Akaike Information Criterion (AIC) or with Schwartz Bayesian Criterion (ABC) (Ahmad, 2012).

The ADF unit root test is based on the below equation of first difference and without intercept and trend

$$\boldsymbol{\Delta Y_t = \partial Y_{t-1} + \sum_{i=1}^{p} B_i \Delta Y + \varepsilon_t}$$

The below equation is with intercept

$$\boldsymbol{\Delta Y_t = \alpha + \partial Y_{t-1} + \sum_{i=1}^{p} B_i \Delta Y + \varepsilon_t}$$

Where the following below equation with intercept and trend (T):

$$\Delta Y_t = \alpha + \partial Y_{t-1} + \gamma T \quad + \sum_{i=1}^{p} B_i \Delta Y_{t-i} + \varepsilon_t$$

The hypothesis test of unit root test is that; the null hypothesis indicates that the estimated variable has unit root, whereas the alternative is; the estimated variable has no unit root or stationery. Therefore, the decision making is conditional on the p-value of the test. If the p-value is greater than the 5% significance level, it indicates that we fail to reject the null hypothesis and the variable is non-stationary. However, if the p-value is smaller than the 5% significance level we reject the null hypothesis and we conclude of stationary of the estimated variable. Additionally, conclusion can be made via the comparison between t-statistics and ADF critical value, if the t-statistics is greater than ADF critical value, thus, the variable is stationary. On the other hand, if the t-statistics is smaller than the ADF critical value, then we failed to reject the null hypothesis and the variable is non-stationary.
The PP test is developed by Philips and Perron (1988) where the equation of this test can be shown as follows

$$\Delta Y_{t-1} = \alpha + \partial Y_{t-1} + \varepsilon_t$$

This test improves the t-statistics of the coefficient ∂ in order to remove the serial correlation in the error term. The PP test makes a correction to the t statistic of the coefficient ∂ from the AR(1) regression to account for the serial correlation in ε_t using nonparametric methods. Once the variable is stationary, then it is said to be integrated of order equal to the number of differencing.
It worth noting, the PP and ADF tests are known to have low power against the alternative hypothesis that the series are stationary with a large autoregressive root (DeJong, et al, 1992). Also, the ADF and PP tests are known to have crucial size distortion (in the direction of over-rejecting the null) when the series has a large negative moving average root (Joshi, 2015).
Ng and Perron (2001) and work by Elliott et al (1996), new tests to deal with both of the mentioned issues. Their tests, in contrast to many of the other "new" unit root tests that have been developed over the years, seem to be a preferred alternative to the traditional ADF and PP tests. The family of Ng-Perron test has the following feature. Firstly, the Ng-Perron tests is a modified lag selection (or truncation selection) criterion. It turns out that the standard lag selection procedures used in specifying the ADF regression (or for calculating the long run variance for the PP statistic) tends to under fit, i.e., choose too small a lag length, when there is a large negative moving average (MA) root. This would create additional size distortion in unit root tests. Secondly, the time series is demeaned or detrended by applying a GLS estimator. This step turns out to improve the power of the tests when there is a large AR root and reduces size distortions when there is a large negative MA root in the differenced series (Joshi, 2015).

Autoregressive Distributed Lag (ARDL) and Nonlinear ARDL (NARDL) Models

This study applies the ARDL approach as proposed by Pesaran and Shin (1999) and extended by (Pesaran et al., 2001). There are bunch of reasons for the adoption ARDL. Mainly, the conventional Johanssen cointegration method uses a system of the equation to estimate the long-run relationship, while ARDL employs a single reduced form equation. Therefore, ARDL approach is an estimator that help to avoid the problem associated with the estimation of short time-series data (Enisan & Olufisayo, 2009). In addition, ARDL estimator does not require variables to be stationary at same level. Hence, it is applied regardless of whether the underlying variables are I(0) or I(1). Moreover, the long and short-run parameters of the model are estimated simultaneously.

$$\Delta lnGGDP_t = \alpha + \beta_1 lnGGDP_{t-1} + \beta_2 lnSTOCKR_{t-1} + \beta_3 lnFINSTA^{+}_{t-1} + \beta_4 lnFINSTA^{-}_{t-1} + \beta_5(lnFINSTA_{t-1} * lnSTOCKR_{t-1}) + \beta_6 lnHC_{t-1} + \beta_7 lnINV_{t-1} + \beta_8 lnPOPG_{t-1} + \beta_9 TRAD_{t-1} + \sum_{i=1}^{n} b_i \,\Delta lnGGDP_{t-1} + \sum_{i=0}^{J} c_i \,\Delta lnSSTOCKR_{t-1} + \sum_{i=0}^{f} K_i \,\Delta lnFINSTA^{-}_{t-1} + \sum_{i=0}^{f} L_i \,\Delta lnFINSTA^{+}_{t-1} + \sum_{i=0}^{q} d_i \,\Delta lnHC_{t-1} + \sum_{i=0}^{p} e_i \,\Delta lnINV_{t-1} + \sum_{i=0}^{l} j_i \,\Delta lnPOPG_{t-1} + \sum_{i=0}^{m} h_i \,\Delta TRAD_{t-1} + \varepsilon_t \qquad Eq(3)$$

For example, the asymmetric effect of financial stability is accounted for by including the positive changes FS_t^{+} and the negative changes FS_t^{-} in Equation (12). FS_t^{+} and FS_t^{-} constitute the partial sums of positive and negative changes in the financial stability, respectively. They are specified as follows:

$$FS_t^{+} = \sum_{i=1}^{t} \Delta FS_t^{+} = \sum_{i=1}^{t} \max(FS_i, 0)$$

$$FS_t^{-} = \sum_{i=1}^{t} \Delta FS_t^{-} = \sum_{i=1}^{t} \min(FS_i, 0)$$

whether asymmetries exist in the long run and short run or not is tested by $\beta_3 = \beta_4$ for financial stability variable and GGDP. $\sum_{i=0}^{f} L_i$ shows the short-run effect of the increases in financial stability on GGDP, while $\sum_{i=0}^{f} K_i$ measures the short-run effect of the decreases on GGDP. The NARDL model is performed irrespective of whether the variables are integrated in order 0 or 1 (I(0) or I(1)). However, it cannot be applied if one of the variables is I(2). Hence, the unit root tests (Augmented Dickey Fuller and Phillip and Perron) are conducted to test the order of integration of the variables. Additionally, to examine the cointegration among the variables, the bound test approach introduced by Pesaran et al (2001); Shin et al (2014) is performed.

Quantile Regression

This method is used for robustness check of the previous method, which is applied to double confirm the augmented results and to confirm the robustness of the results and make a conclusion. Quantile regressions were first introduced by Koenker & Bassett (1978) as a robust regression technique that allows for estimation when the assumption of normality of the error term might not be strictly satisfied (Lee & Law, 2017). The quantile regression can be written as follows

$$lnGGDP_t = X_t'\beta_\theta + \mu_{0t} \; : \quad Q_\theta(A_t/X_t) = X_t'\beta_\theta \qquad Eq(4)$$

where $lnGGDP_t$ denotes China's green GDP, Xi is the vector of the independent variables, β_θ is the vector of parameters to be estimated for a given value of the quantiles θ. Where, $Q_\theta(A_t/X_t)$ is the θth quantile of the conditional distribution of the green GDP given the vector of explanatory variables Xi. In addition, quantile parameters are estimated by solving a minimization problem where the corresponding residuals have to be weighted. Notably, the robust covariance matric are computed by following the studies of (Chamberlain, 1994; Powell, 1984; Angrist et al., 2006).

The quantile regression has been used in growth studies (Mello and Perrelli, 2003; Osborne, 2006). The study of Mello and Perrelli in (2003) used quantile regression technique to examine the role of income convergence and the effects of policy variables on the conditional distribution of GDP. The findings using cross-sectional data evidenced of significant changes in the slope coefficients of independent variables across the quantiles. The second study of Osborne (2006) also considers how the coefficients on a number of standard growth determinants differ across quantiles; his results found significant differences across quantiles in the coefficients on the explanatory variables (Foster, 2008).

The sample country of this study is China and the sample period is covering from 2002 to 2018 of 17 years, where the quarterly datasets are used in the analysis with 124 total observations. The green GDP is calculated based on the formula mentioned earlier. Notably, the major source of the data for cities is the "China City Statistic Year Book". The Year Book provides information on cities' air and water pollution, financial development, economic index, and investment statistics among other statistics that will be used for this study.

The financial stability variable is proxied by the bank z score. It captures the probability of default of a country's banking system, calculated as a weighted average of the z-scores of a country's individual banks (the weights are based on the individual banks' total assets). Z-score compares a bank's buffers (capitalization and returns) with the volatility of those returns. Stock return variable is proxied by stock return index retrieved from Hushen300 DataStream source; this variable has been used by several previous studies for instance the study of (Guidolin et al., 2009). Where human capital's proxy is life expectancy at birth, total (years), the data were taken from World Bank. In addition, openness is defined as the sum of exports and imports divided by GDP, the data of trade openness is obtained from World Bank. Population refers to total number of inhabitants of a given area or a country, population concentration is where the chunk of population is settled in a given location. In this study population is proxied by population density per square kilometer. Investment refers to financial commitments into business with aim of making returns from it.

Table 1
Summary of data

Variables	Measurement	Data source
Net forest depletion	The product of unit resource rents and the excess of roundwood harvest over natural growth.	World Bank
Mineral depletion	The ratio of the value of the stock of mineral resources to the remaining reserve lifetime.	World Bank
Energy depletion	The ratio of the value of the stock of energy resources to the remaining reserve lifetime.	World Bank
Stock return (STOCKR)	Hushen 300 Increase and decrease (%)	Hibor economy database
Financial stability (FINSTA)	The probability of default of a country's banking system	Global Financial Development
Human Capital (HC)	Life expectancy at birth, total (years).	World Development Indicators.
Trade Openness (TRAD)	Trade (% of GDP), Export plus import divided by GDP.	World Development Indicators.
Population (POP)	Population density.	World Development Indicators.
Investment (INV)	Gross capital formation as a percentage of GDP.	World Development Indicators.

Results and Discussion

Table 2 below presents the descriptive statistics of the variable used in the analysis. The mean value of Green GDP is 27.870 having a standard deviation of 0.753; stock return has an average value of 0.356, while its standard deviation is 1.478, and the financial stability is 1.37. Population shows an average value of 0.535 with a standard deviation of 0.057. The mean of human capital and investment are 18.315 (stand. dev. 0.616) and 10.570 (stand. dev. 0.789) respectively. The mean value of trade openness is 10.863 having a standard deviation of 0.817.

Table 2
Descriptive Statistics

Variable	Unit of Measurement	Obs	Mean	Std Dev	Min	Max
Green GDP[1]	Yuan	68	27.870	0.753	26.522	28.911
Stock Return	Percent	68	0.356	1.478	-3.26	6.71
Financial Stability	Rank	68	14.743	1.372	11.921	17.608
Population growth	Percent	68	0.535	0.057	0.419	0.692
Human capital	Years of schooling	68	18.315	0.616	16.894	19.196
Investment	% of GDP	68	10.570	0.789	8.460	11.691
Trade openness	% of GDP	68	10.863	0.817	8.677	11.981

Table 3 presents the results of the correlation among the variables, green GDP, stock return, financial stability, population growth, human capital, investment and trade openness. Variables of interest in this study are shown to have a positive correlation with green GDP; however, population growth is negatively correlated with green GDP. The variables of stock return, financial stability human capital, investment, and trade openness have positive correlation with green GDP. The highest correlation is indicated between trade openness and investment with 0.98, and between human capital and population with 0.99, while other correlations are considered at reasonable level.

Table 3
Correlations

	GGDP	HC	INVEST	POPG	STOCKR	TRAD	FINSTA
GGDP	1.000						
HC	0.475	1.000					
INV	0.502	0.636	1.000				
POPG	-0.610	-0.384	-0.785	1.000			
STOCKR	0.302	0.055	0.205	-0.296	1.000		
TRAD	0.527	0.647	0.988	-0.755	0.217	1.000	
FINSTA	0.755	0.692	0.319	-0.376	0.181	0.353	1.000

Note: GGDP= Green Gross Domestic Produc, HC: human capital, INV: investment, POPG: population growth, STOCKR: stock return, TRAD: trade openness, FINSTA: financial stability.

Results of Unit Root Tests

Table 4 reports the unit root tests of Augmented Dickey Fuller (ADF) and Phillip-Perron tests. The findings indicate that at level, stock return is stationary at level or integrated of order zero, I(0) based on the ADF test. However, more variables are stationary at I(1) using the Phillip-Perron test, namely stock return, human capital, investment and trade openness. The first difference series demonstrate that all variables are stationary at first differences or I(1).

[1] The green GDP is in log form.

Therefore, there are mixed results of I(0) and I(1) of the series time series properties. This finding reveals that due to mixed result of integration, the ARDL model is suitable to analyse the long-run and short-run relationships.

Table 4
Results of Unit Root Tests

Variable	Augmented Dickey Fuller (ADF)	Phillips-Perron (PP)
Level		
	Constant without trend	Constant with trend
Green GDP	-2.282	-4.111***
Stock return	-9.150***	-9.109***
Population growth	-1.898	-2.201
Human capital	-4.203*** I(0)	-48.160*** 1(0)
Investment	-1.648	-3.966** I(0)
Trade openness	-1.277	-3.733** I(0)
Financial stability	-2.708	-2.488
First Difference		
	Constant without trend	Constant with trend
Green GDP	-1.846	--20.021 ***
Stock return	-8.843***	-50.268***
Population growth	-2.352	-2.114
Human capital	-13.859***	-72.319***
Investment	-3.239**	-18.036***
Trade openness	-2.481	-14.7353***
Financial stability	-3.371***	-16.459***

Note: *** and ** denote significant at 1% and 5% levels, respectively. Between the brackets are lag level.

The Unrestricted Vector-Error Correction Model and Bounds test – Stock Return-Financial Stability Interaction ON Green GDP

Table 5 present the Results of unrestricted error correction Interaction model (UECM) before obtaining the bounds cointegration test. The optimal lag structure is selected by general to specific criterion which is ARDL (1, 3, 1, 0, 3, 0, 3, 0). Subsequently, the bounds cointegration test is based on the same lag structure where the UECM model is passed the serial correlation and stability tests.

Table 5
Results of Unrestricted Error-Correction Model (UECM)
[Financial stability x Stock Return]
Dependent variable: LGGDP
ARDL(1, 3, 1, 0, 3, 0, 3, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LGGDP(-1)	0.7957	0.0611	13.023	0.0000
STOCKR	0.0016	0.0025	0.6355	0.5283
STOCKR(-1)	-0.0005	0.0026	-0.1853	0.8538
STOCKR(-2)	0.0050	0.0026	1.9373	0.0590
STOCKR(-3)	0.0034	0.0024	1.4118	0.1649
FINSTA	0.0122	0.0175	0.6986	0.4884
FINSTA(-1)	0.0211	0.0173	1.2164	0.2302
STOCKR*FINSTA	0.0025	0.0025	1.0107	0.3175
HC	-0.0248	0.0281	-0.8836	0.3816
HC(-1)	0.2151	0.0232	9.2525	0.0000
HC(-2)	0.0119	0.0330	0.3622	0.7189
HC(-3)	0.0472	0.0288	1.6363	0.1087
INV	0.1136	0.0510	2.2252	0.0311
POPG	-1.2483	0.6028	-2.0706	0.0442
POPG(-1)	2.3259	1.0649	2.1841	0.0342
POPG(-2)	0.0896	1.0945	0.0818	0.9351
POPG(-3)	-1.4320	0.6594	-2.1717	0.0352
TRADE	-0.0872	0.0543	-1.6033	0.1159
C	0.8986	0.4208	2.1352	0.0382

Note: GGDP= Green Gross Domestic Produc, HC: human capital, INV: investment, POPG: population growth, STOCKR: stock return, TRAD: trade openness, FINSTA: financial stability

The bounds test of cointegration is reported in table 6 where the interaction term using the demean method. The method has generated a new variable to test the interaction effect. The result shows cointegration because the F-statistic 15.7289 is greater than critical value of upper bound level, therefore, there is a long-run cointegration or the variables are moving together in the long-run.

Table 6
Bounds Cointegration Test with interaction between Stock Return and Financial Stability using Demean Method

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Finite Sample: n=65	
F-statistic	15.72890	10%	2.043	3.094
k	7	5%	2.373	3.519
		1%	3.092	4.478
Actual Sample Size	64			

The long-run estimation of the interaction between Stock Return and Financial Stability is reported in Table 7. The result demonstrates the interaction term (STR * FINSTA) is significant at 2 percent level. This means that financial stability complements stock return to promote green GDP. Other variables that significant determinant of green GDP are human capital and investment. Next, the error-correction short-run results are estimated to verify the bounds test long-run relationship by estimating the error-correction term.

Table 7
Long-Run Estimation of the Interaction Term between Stock Return and Financial Stability

Variable	Coefficient	Std. Error	t-Statistic	Prob.
STOCKR	0.0473	0.0341	1.3839	0.1732
FINSTA	0.0127	0.0133	0.9487	0.3478
STOCKR*FINSTA	0.1636	0.0706	2.3145	0.0253
HC	1.2214	0.2018	6.0523	0.0000
INV	0.5566	0.2825	1.9702	0.0550
POPG	-1.2970	1.1105	-1.1678	0.2490
TRAD	-0.4270	0.2933	-1.4556	0.1524
C	4.4005	2.9882	1.4726	0.1478

Note: HC: human capital, INV: investment, POPG: population growth, STOCKR: stock return, TRAD: trade openness, FINSTA: financial stability

Table 8 presented the results of Short-run Dynamic Effect of interaction term between stock return and financial stability. The expected signs of the variables are not followed the theory due to the short-run is a dynamic process. The main concern is the interaction term between stock return and financial stability. The finding indicates that the interaction term is insignificant in the short-run because the p-value is greater than 0.05. The ECT term is negative coefficient and significant, justify the long-run cointegration result.

Table 8
ARDL Error Correction Regression with interaction between Stock Return and Financial Stability
Dependent variable: D(LGGDP)
ARDL(1, 3, 1, 0, 3, 0, 3, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
∆ (STOCKR)	0.0016	0.0019	0.8663	0.3909
∆ (STOCKR(-1))	-0.0085	0.0022	-3.7445	0.0005
∆ (STOCKR(-2))	-0.0034	0.0018	-1.8679	0.0683
∆ (FINSTA)	0.0122	0.0141	0.8678	0.3901
∆ (HC)	-0.0248	0.0072	-3.4282	0.0013
∆ (HC(-1))	-0.0591	0.0131	-4.4911	0.0000
∆ (HC(-2))	-0.0472	0.0069	-6.8408	0.0000
∆ (POPG)	-1.2483	0.4489	-2.7804	0.0079
∆ (POPG(-1))	1.3424	0.5961	2.2518	0.0293
∆ (POPG(-2))	1.4320	0.4995	2.8664	0.0063
ECT(-1)*	-0.2042	0.0158	-12.912	0.0000

Note: GGDP= green GDP, HC= human capital, INV=investment, POPG=population growth, STOCKR=stock return, TRAD=trade openness, FINSTA=financial stability..

The diagnostic tests using the Breusch-Godfrey serial correlation test, CUSUM and CUSUM square stability tests. It indicates that the error terms of the ARDL model are uncorrelated where the p-values of the N x R^2 are greater than 0.05, which reveal that no serial correlation problem. The CUSUM and CUSUM square as depicted in Figures 2 and 3, show that the stability of the ARDL model since the lines are fall within the upper and lower bounds.

Table 9
Results of Serial Correlation Diagnostic

Breusch-Godfrey Serial Correlation LM Test			
Lag = 2			
F-statistic	1.0847	Prob. F(2,43)	0.3470
Obs*R-squared	3.0739	Prob. Chi-Square(2)	0.2150
Lag = 4			
F-statistic	1.02972	Prob. F(4,41)	0.3335
Obs*R-squared	4.10367	Prob. Chi-Square(4)	0.2070

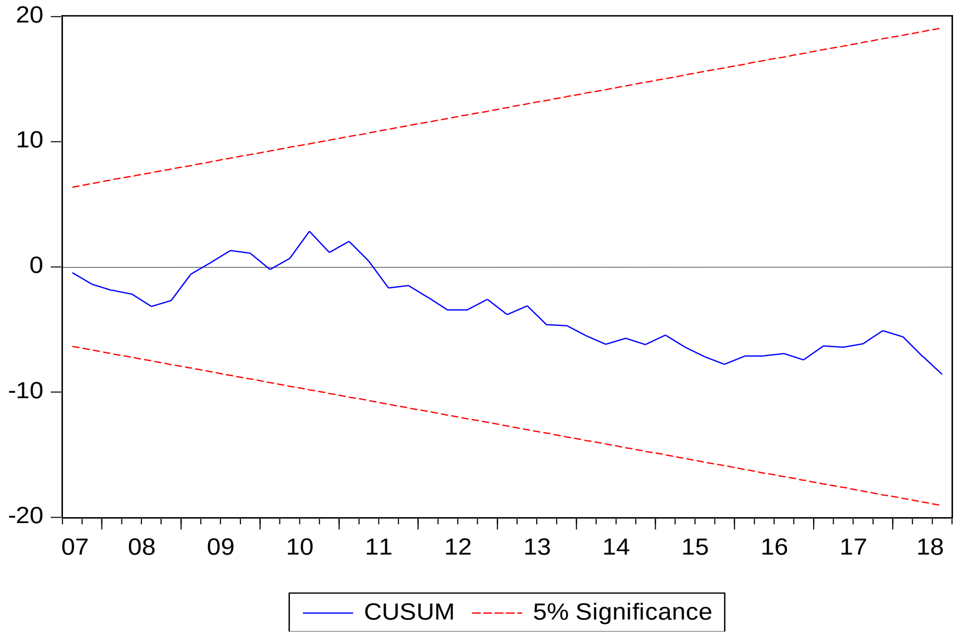

Figure 2: CUSUM stability test result [Stock return*Financial Stability]

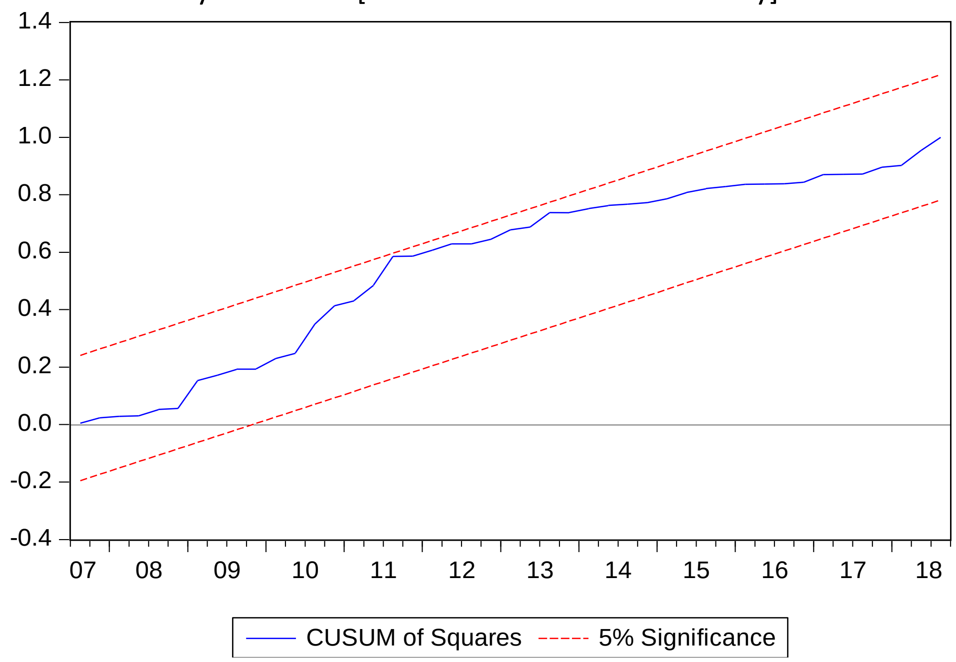

Figure 3: CUSUM square stability test result [Stock return*Financial Stability]

The Unrestricted Vector-Error Correction Model and Bounds test – Stock Return-Financial Stability Interaction on GDP

Table 10 below presents the results of unrestricted error correction model with interaction term between stock return and financial stability. The purpose of estimating this result is to compare the effects of stock return and financial stability on GDP in addition the green GDP. The optimal lag structure is selected by general to specific criterion which is ARDL (2, 0, 1, 0, 1, 3, 3, 1). Subsequently, the bounds cointegration test is based on the same lag structure where the UECM model is passed the serial correlation and stability tests.

Table 10
Results of Unrestricted Error-Correction Model (UECM)
[Financial Stability x Stock Return]
Dependent variable: GDP
ARDL (2, 0, 1, 0, 1, 3, 3, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LGDP(-1)	1.0643	0.1210	8.7954	0.0000
LGDP(-2)	-0.2635	0.1210	-2.1768	0.0347
STOCKR	-0.0065	0.0099	-0.6617	0.5114
FINSTA	0.0062	0.0127	0.4950	0.6229
FINSTA(-1)	0.0294	0.0135	2.1803	0.0344
STOCKR_FINSTA	0.0014	0.0019	0.7253	0.4719
INV	-0.0374	0.0455	-0.8216	0.4155
INV(-1)	0.1686	0.0682	2.4724	0.0172
HC	-0.0088	0.0228	-0.3850	0.7019
HC(-1)	0.2214	0.0331	6.6829	0.0000
HC(-2)	-0.0276	0.0274	-1.0084	0.3185
HC(-3)	0.0680	0.0265	2.5593	0.0138
POPG	-0.1583	0.4226	-0.3745	0.7097
POPG(-1)	0.9603	0.7382	1.3007	0.1998
POPG(-2)	-0.1965	0.7268	-0.2703	0.7881
POPG(-3)	-0.7044	0.4139	-1.7018	0.0955
TRADE	0.0666	0.0429	1.5536	0.1271
TRADE(-1)	-0.1647	0.0676	-2.4352	0.0188
C	0.53	0.4210	1.2697	0.2106

Note: GDP= Gross Domestic Produc, HC: human capital, INV: investment, POPG: population growth, STOCKR: stock return, TRAD: trade openness, FINSTA: financial stability

The bounds test of cointegration is reported in table 11 below where the interaction term using the demean method. The method has generated a new variable to test the interaction effect. The result confirms a cointegration because the F-statistic 6.75 is greater than the critical value of upper bound level. Therefore, there is a long-run cointegration or the variables are moving together in the long-run.

Table 11
Bounds Cointegration Test with interaction between Stock Return and Financial Stability

F-Bounds Test	Null Hypothesis: No levels relationship			
Test Statistic	Value	Signif.	I(0)	I(1)
			Finite Sample: n=65	
F-statistic	6.7539	10%	2.043	3.094
k	7	5%	2.373	3.519
		1%	3.092	4.478
Actual Sample Size	65			

The long-run estimation of the interaction between stock return and financial stability is reported in table 12. The result demonstrates the interaction term (STR * TINSTA) is not significant at 5% level. This means that financial stability does not complements stock return to promote GDP, or this variable does not play an important role in moderating the effect of stock return on GDP, but its only work for green GDP. Other variables that significant determinant of GDP are human capital, trade and investment. Next, the error-correction short-run results are estimated to verify the bounds test long-run relationship by estimating the error-correction term.

Table 12
Long-Run Estimation of the Interaction Term between Stock Return and Financial Stability

Variable	Coefficient	Std. Error	t-Statistic	Prob.
STOCKR	-0.0329	0.0507	-0.6482	0.5201
FINSTA	0.1795	0.0606	2.9615	0.0048
STOCKR * FINSTA	0.0072	0.0101	0.7101	0.4812
INV	0.6588	0.2289	2.8775	0.0061
HC	1.2702	0.1859	6.8330	0.0000
POPG	-0.4966	0.8980	-0.5530	0.5829
TRADE	-0.4926	0.2217	-2.2219	0.0312
C	2.6844	2.4734	1.0853	0.2834

Note: HC= human capital, INV=investment, POPG=population growth, STOCKR=stock return, TRAD=trade openness, FINSTA=financial stability

Table 13 below presented the results of short-run dynamic effect of interaction term between stock return and financial stability. The expected signs of the variables are not followed the theory due to the short-run is a dynamic process. The main concern is the interaction term between stock return and financial stability. The finding indicates that the interaction term is insignificant in the short-run because the p-value is greater than 0.05. The ECT term is negative coefficient and significant, justify the long-run cointegration result.

Table 13
ARDL Error Correction Regression with interaction between
Stock Return and Financial Stability
Dependent variable: ∆GDP
ARDL(2, 0, 1, 0, 1, 3, 3, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
∆ (GDP(-1))	0.2635	0.0812	3.2441	0.0022
∆ (FINSTA)	0.0062	0.0100	0.6285	0.5327
∆ (INV)	-0.0374	0.0348	-1.0757	0.2877
∆ (HC)	-0.0088	0.0140	-0.6266	0.5340
∆ (HC(-1))	-0.0403	0.0248	-1.6255	0.1109
∆ (HC(-2))	-0.0680	0.0059	-11.434	0.0000
∆ (POPG)	-0.1583	0.2996	-0.5282	0.5998
∆ (POPG(-1))	0.9009	0.3767	2.3912	0.0209
∆ (POPG(-2))	0.7044	0.3501	2.0117	0.0501
∆ (TRADE)	0.0666	0.0284	2.3440	0.0235
ECT(-1)	-0.1991	0.0235	-8.4473	0.0000

Note: GDP= Gross Domestic Product, HC: human capital, INV: investment, POPG: population growth, STOCKR: stock return, TRAD: trade openness, FINSTA: financial stability

Based on the finding, the interaction term is significant determinant of green GDP but not GDP. This indicates that the results are different when the dependent variable is changed to GDP instead of green GDP.

Nonlinear ARDL Model and Bounds test between Stock Return and Financial Stability interaction on GGDP

The nonlinear ARDL approach is applied for this objective, because the possibility of stock return asymmetric effect on green GDP in China, particularly the stock return and stability of financial system, in the long and short run. The NARDL model allows whether positive and negative of financial stability shocks have any impacts on GGDP. Table 14 differentiated the result between the positive and negative impact of stock return.

Table 14
ARDL Unrestricted Error-correction Model between
stock return and financial stability
Dependent variable: LGGDP
ARDL(1, 1, 0, 0, 2, 0, 2, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LGGDP(-1)	0.8922	0.0431	20.706	0.0000
STOCKR	-0.0009	0.0026	-0.3527	0.7257
STOCKR(-1)	-0.0039	0.0024	-1.5963	0.1165
FINSTA_POS	0.0358	0.0124	2.8693	0.0059
FINSTA_NEG	0.0324	0.0134	2.4231	0.0189
HC	-0.0851	0.0139	-6.1161	0.0000
HC(-1)	0.1848	0.0087	21.202	0.0000
HC(-2)	-0.0450	0.0089	-5.0494	0.0000
INV	0.0326	0.0385	0.8462	0.4013
POPG	-0.7701	0.6062	-1.2703	0.2096
POPG(-1)	2.3024	1.0402	2.2135	0.0313
POPG(-2)	-1.4383	0.5945	-2.4191	0.0191
TRADE	0.0014	0.0355	0.0397	0.9685
C	1.5404	1.2177	1.2650	0.2115

Note: GGDP=Green Gross Domestic Product, HC: human capital, INV: investment, POPG: population growth, STOCKR: stock return, TRAD: trade openness, FINSTA: financial stability

Table 15 is the ARDL Bounds test for interaction between stock return and financial stability. The result shows the F-statistic is greater than the upper bound critical value, therefore, there is a cointegration relationship among the variables or they are moving together in the long-run.

Table 15
Bounds Cointegration Test with interaction between Stock Return and Financial Stability using Demean Method

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	16.71497	10%	1.85	2.85
K	8	5%	2.11	3.15
		2.5%	2.33	3.42
		1%	2.62	3.77
Actual Sample Size 66			Finite Sample: n=65	

NARDL results of interaction term between stock return and financial stability is reported in table 16. The result indicates that the positive and negative interaction is insignificant determinants of green GDP. The interaction term (STOCKR * FINSTA) is significant at 5 percent level. This means that financial stability complements stock return to promote green GDP. Human capital, investment and trade are positive and significant determinants of green GDP.

Table 16
Long-Run Estimation of Interaction between
Stock Return and Financial Stability
Dependent variable: Green GDP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
STOCKR	-0.0450	0.0430	-1.0465	0.3002
FINSTA_POS	0.3323	0.1169	2.8417	0.0064
FINSTA_NEG	0.3011	0.2027	1.4854	0.1435
HC	0.5067	0.3162	1.6022	0.1152
INV	0.3028	0.3932	0.7701	0.4447
POPG	0.8727	1.9950	0.4374	0.6636
TRADE	0.0131	0.3279	0.0399	0.9683
C	14.293	6.0427	2.3653	0.0218

Note: GGDP= Green Gross Domestic Product, HC: human capital, INV: investment, POPG: population growth, STOCKR: stock return, TRAD: trade openness, FINSTA: financial stability

Table 17 shows the short-run dynamic model of interaction term between stock return and financial stability. The interaction term is insignificant in the short-run because the p-value is greater than 0.05. The ECT term is negative coefficient and significant, justify the long-run bounds cointegration test where the variables are moving together in the long-run. The other variables are not consistent with the theory due to the short-run is dynamic.

Table 17
Results of Short-run Dynamic Effect of Interaction Term
between stock return and financial stability
Dependent Variable: Δ (LGGDP)
ARDL(1, 3, 0, 0, 0, 1, 1, 3, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Δ (STOCKR)	-0.0008	0.0014	-0.5585	0.5786
Δ (HC)	-0.0665	0.0165	-4.0298	0.0002
Δ (HC(-1))	0.0440	0.0056	7.8297	0.0000
Δ (FINSTA_POS)	0.0149	0.0183	0.8123	0.4200
Δ (FINSTA_NEG)	0.0132	0.0226	0.5824	0.5626
Δ (POPG)	-0.9272	0.4878	-1.9005	0.0624
Δ (POPG(-1))	1.4103	0.5015	2.8120	0.0067
D(TRADE)	0.0124	0.0232	0.5336	0.5957
ECT(-1)	-0.1112	0.0101	-11.1201	0.0000

Note: GGDP= Green Gross Domestic Product, HC: human capital, INV: investment, POPG: population growth, STOCKR: stock return, TRAD: trade openness, FINSTA: financial stability

Table 18 shows the result of Wald Test, it indicates that the p-value is greater than 0.05, which reveal that both are the same and no asymmetric in the long-run for the interaction term. Restrictions are linear in coefficients

Table 18
Wald Test: Restriction

Test Statistic	Value	df	Probability
t-statistic	-1.515538	45	0.1366
F-statistic	2.296856	(1, 45)	0.1366
Chi-square	2.296856	1	0.1296

Null Hypothesis: C(5)=C(6)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(5) - C(6)	-0.019406	0.012805

Figures 4 and 5, show that the stability of the NARDL model, CUSUM and CUSUM square are within the bounds and the model is stable.

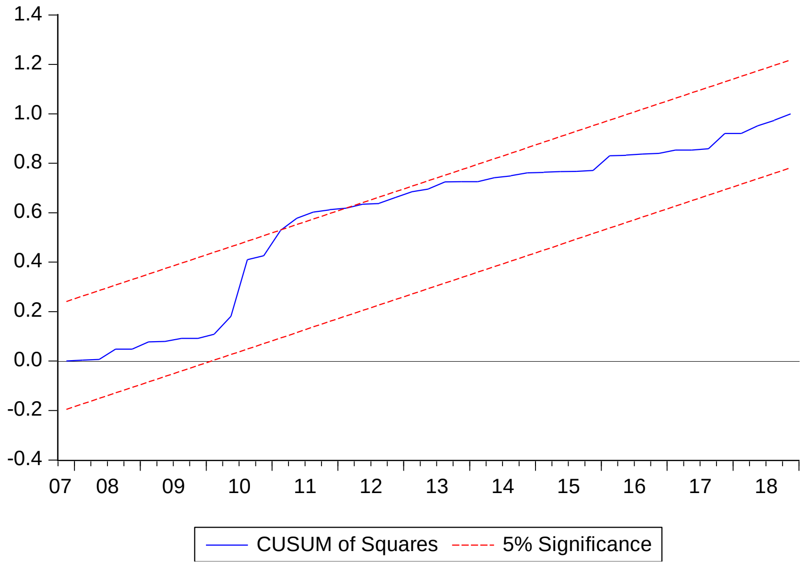

Figure 4: CUSUM stability test [Stock return*Financial Stability]

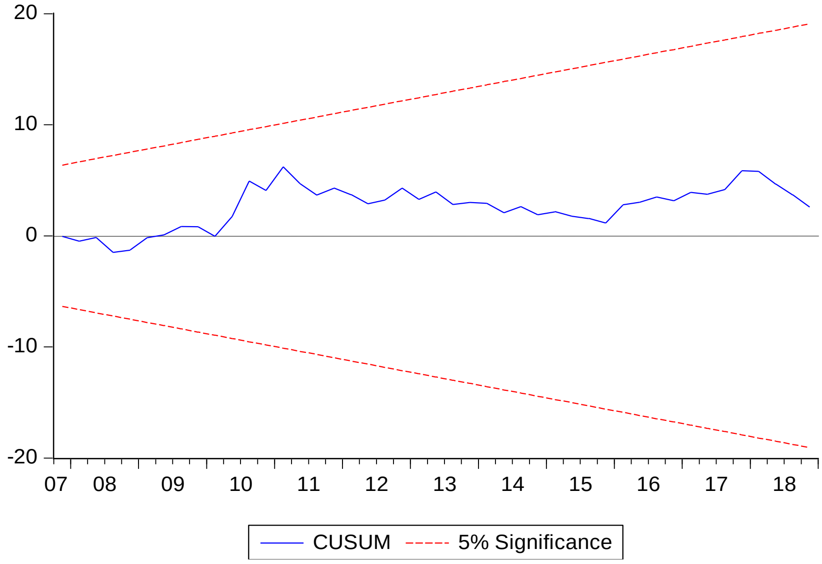

Figure 5: CUSUM square stability test [Stock return*Financial Stability]

Robustness Checks using quantile Regression

The quantile regression results reported in Table 19 demonstrate that the financial stability is statistically significant determinant of green GDP where the 30 quantile until 90 quantile show significant results. This indicates that financial stability is more dominant if compared to stock return in promoting green GDP. At the low quantile where the green GDP is low, the financial stability is insignificant. Therefore, financial stability would not affect green GDP when green GDP is low, but it pays an important role when the green GDP is high.

Table 19
Quantile Regression Results

VARIABLES	(1) q10	(2) q20	(3) q30	(4) q40	(5) q50	(6) q60	(7) q70	(8) q80	(9) q90
STOCKR	0.00322	0.00243	0.00246	0.00502	0.00488	0.00442	-0.0112	-0.0209	0.00247
	(0.0322)	(0.0384)	(0.0473)	(0.0410)	(0.0431)	(0.0322)	(0.0363)	(0.0430)	(0.0562)
FINSTA	0.163	0.291	0.527**	0.706***	0.724***	0.755***	0.733***	0.667***	0.668***
	(0.256)	(0.287)	(0.238)	(0.156)	(0.165)	(0.0678)	(0.0667)	(0.0860)	(0.0999)
HC	-0.289	-0.388	-0.396	-0.460*	-0.499*	-0.480**	-0.438***	-0.316***	-0.329***
	(0.514)	(0.339)	(0.296)	(0.275)	(0.268)	(0.188)	(0.138)	(0.109)	(0.0725)
POPG	-5.393	-2.285	1.443	6.672*	5.518	3.182	2.063	-0.699	-0.0996
	(5.230)	(5.952)	(4.903)	(3.717)	(3.941)	(2.425)	(2.345)	(2.496)	(2.679)
INV	-2.678**	-2.007	-0.767	0.134	0.409	0.743	0.474	-0.235	-0.159
	(1.246)	(1.283)	(1.113)	(0.744)	(0.534)	(0.445)	(0.491)	(0.552)	(0.427)
TRADE	2.862**	2.398*	1.328	0.586	0.153	-0.384	-0.193	0.354	0.300
	(1.203)	(1.246)	(1.078)	(0.797)	(0.619)	(0.377)	(0.376)	(0.427)	(0.388)
Constant	32.18***	29.77***	25.46***	21.70***	24.90***	28.07***	28.80***	30.00***	29.72***
	(8.105)	(4.374)	(3.045)	(2.751)	(1.799)	(1.786)	(2.167)	(1.857)	(2.207)
Observations	68	68	68	68	68	68	68	68	68

Note: HC: human capital, INV: investment, POPG: population growth, STOCKR: stock return, TRAD: trade openness, FINSTA: financial stability

Figure 6 depicts the quantile regression result coefficients of each variable. As shown in this figure, the stock return has constant coefficients due to the graph is stable until 60 percentiles fluctuate. The financial stability shows an upward trend then becomes stable at higher quantile levels.

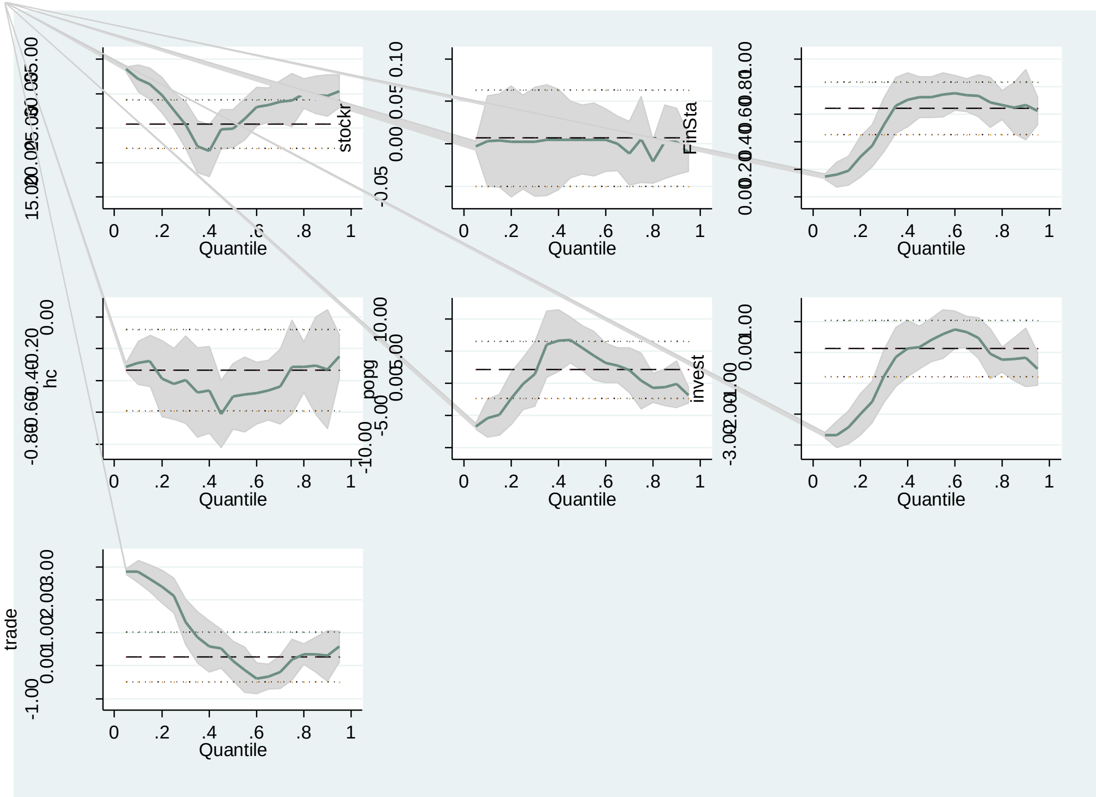

Figure 6: The Coefficients of Various Quantiles of the Variables
(Model: Stock return x Financial Stability)

Conclusion

This study attempts to uncover the indirect link between stock return and green GDP in the presence of financial stability. Past studies gave mixed results on this issue, and results are still ambiguous. Therefore, this reason motivates this study to include the interaction of financial stability as an induce factor on the stated link. Another motivation of this study is to compare the result between green GDP and normal GDP results, because past few studies did a comparison between GDP and green GDP. The augmented results contribute to the existing literature in terms of which GDP is crucial in the country. Finally, it worth noting that stock return increases green GDP, but harm environment such as increase emissions. The role of financial stability that enhances the level of financial system in the country would significantly mitigate the negative impact. Therefore, financial stability is prerequisite factor to have better environment conservations.

The interaction link between stock return and financial stability on green GDP. The quantile regression results reported in Table 20 demonstrate that the financial stability is statistically significant determinant of green GDP where the 30 quantiles until 90 quantile show significant results. This indicates that financial stability is more dominant if compared to stock return in promoting green GDP. At the low quantile where the green GDP is low, the financial stability is insignificant. Therefore, financial stability would not affect green GDP when green GDP is low, but it pays an important role when the green GDP is high.

Policymakers use Green GDP as a measure of societal well-being. Green GDP considers external costs that GDP does not. On the other hand, it is also suggested that Green GDP outperforms GDP in terms of CO2 emissions reduction. The use of Green GDP can help to promote the existence of the ECK hypothesis in the future. At the same time, Green GDP can help to promote green growth, which aims to reduce pollution.

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