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The dynamic conditional correlation of stock and bond returns

Empirical evidence of China from October 2007 to June 2016

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Abstract

This thesis investigates the relationship between stock and bond market in China by testing the hypothesis of time-varying correlation between stock and bond returns. The Dynamic Conditional Correlation (DCC) GARCH model, as introduced by Engle in 2001, is used to estimate these correlations. Eleven macroeconomic factors are used in six linear regressions in order to see their impacts on the stock-bond correlation. The empirical analysis is conducted from October 2007 until June 2016. The empirical results show that the SSE-B/Bond return correlation is more volatile than the SSE-A/Bond return correlation during financial stress periods exhibiting flight-to-safety effects. The analysis has shown that, the B-shares market is affected by different macroeconomic factors than the A-shares market. The results of study provide investors recommendations on portfolio optimization.

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Chapter 1: Introduction

1.1 Research Path

The structure of the thesis includes a detailed introduction that is intended to explain the research aims, objectives, questions, significance, and research methodology. The first chapter gives a complete overview of the entire thesis, except the research findings. In the second chapter, literature review, studies of different renowned authors have been analyzed considering the research questions. The main purpose of this chapter is to formulate an enhanced understanding of the research topic, which will further help in concluding the results. In the third chapter, the Chinese stock and bond markets are explored in order to comprehend their structures and their functioning. In the fourth chapter, research methodology is presented on which the entire study is based. Similarly to the most recent studies on the topic, we apply the Dynamic Conditional Correlation (DCC) version of the multivariate GARCH model by Engle (2002) to verify our initial hypotheses.

The fifth chapter, including empirical results and interpretations, provides findings extracted from the selected research methodology. Alongside, the explored findings and results are analyzed to meet research objectives and research questions. Finally, in the sixth chapter, a summary of the empirical results are presented followed by the implications on asset allocation and limitations of the study and further researches.

1.2 Research Background

A stock market, share market or equity market is the aggregation of sellers and buyers (Zhang and Edwards, 2015). It is a loose network of stocks, which is also known as shares that might comprise securities listed on a stock exchange. The stock market of the country provides significant paths for business companies to increase capital, along with debt markets, which are commonly more imposing in nature, but do not publicly traded. The stock market facilitates businesses to be openly traded, and increases extra fiscal capital for development by selling ownership shares of the company in an open market (Zhang and Edwards, 2015).

The liquidity in the stock exchange allows shareholders to easily and quickly sell securities. This is a striking feature of investing in stocks or shares, as compared to other less liquid investments, such as immoveable assets and property. Some companies dynamically raise liquidity by trading their own shares (Underwood, 2014). History has revealed that the price of assets including stock is an imperative component of the dynamics of any country's monetary activity, and can manipulate or be a gauge of social mood. A financial system where the stock market is on rise is regarded to be a flourishing economy. Indeed, the stock market is usually considered the major sign of the economic strength and development of a country (Krishnan, Petkova and Ritchken, 2013).

For instance, rising share prices are likely to be related to improved investment in business and vice versa. In addition, share prices also have an effect on the consumption and the wealth of households. Consequently, central banks have a propensity to keep a strict eye on the behaviour and control of the stock market and, generally, on the functions of the financial system's operations (Kong, 2012). Furthermore, the Global Financial Crisis of 2008 has provoked a finely tuned degree of inspection of the effects of the stock markets structure or market microstructure, especially regarding the financial system stability and the systemic risk transmission. These economic crises have completely transformed the nature of stock markets by encouraging the influence of the bond market on stock market returns (Chordia, Sarkar and Subrahmanyam, 2015).

Like many other countries, more specifically, in China, exchanges in the stock market also perform as the clearing agent for every transaction, which means that the stock market makes sure of the payment to the security seller by collecting and delivering the shares. This reduces the risk of an individual seller or buyer about the counterparty defaults on the transaction. These operations ensure the availability of a maximum of stock market returns. In addition, the smooth execution of all these activities allows economic development in that enterprise's risks and lower costs encourage the production of services and goods. Thus, the financial system of China contributes to increased wealth; however, certain level of controversy prevails that whether the optimal economy is market-based or bank-based (Chan and Chang, 2014).

Similarly, the Chinese stock market has experienced evolution in the wake of the financial crisis of 2008. The role of the bond market is more evident in the stock market and in the overall economy of China. After coming out of the financial crisis successfully, China has entered a new stage in its transition from a planned to an open economy (Chen, Chen and Gong, 2012). The management of the major state banks, as well as the balance sheets of these institutions, has significantly improved. The banking sector is taking large benefits from the growth of bond markets. The common benchmark existence for the prosperity of employed capital, and the capacity for banks to control their liquidity, both need a precise yield curve beached on a government bond market (Chen, Chen and Gong, 2012).

In developed financial systems like that of China, bank credit and bond financing are paired. The financial systems of Asian countries are heavily inclined towards banks. The government of China found it suitable to allow broad branch networks owned by profitable banks. Likewise, after the stock market crash due to the 2008 financial crisis, China has learned the lesson to make their bond market strong and makes sure of its maximum involvement in the stock market operations. After this crisis, the relationship between stock and bond market is further established and further strengthened. According to the economy policy of China, the issuance of corporate bond and improvement in the stock market are long-term objectives (Chan and Chang, 2014). Therefore, in order to understand the evolved nature of the stock market it is highly important to construct a research based on the correlation between the bond market and stock market returns.

1.3 Chinese Market Historical overview

In the wake of 1978 market reforms, China has become a market-based economy from a centrally planned economy. As a result, the country has experienced rapid socio-economic development. Since then, the GDP has increased almost 10% per year and has taken more than 850 million people out of line of poverty, the best ever-constant growth by a main economy in history. China, by 2015, with the help of their progressive and farsighted economic policy, successfully accomplished all the Millennium Development Goals (MDGs) and contributed their major part in the reaching of the MDGs internationally (Wu & Bowe, 2010).

The current exchange was re-organized in November 1990 after a 41-year pause and became functional in the same year. It is a non-profitable organization administered directly by the China Securities Regulatory Commission (CSRC). With an extremely crowded population of around 1.3 billion, China is world's second leading economy and is playing an important and influential role in the global economy. Nonetheless, China still remains a developing country and its market reforms are still under process due to the fact that the per capita income of the country is still not compatible with that in advanced countries. Rapid economic rise has also resulted in several challenges, including rapid urbanization; high inequality; external imbalances and challenges to environmental sustainability. China, in addition, experiences demographic pressures associated to the internal migration of labour and a swelling population (Yanhua, 2015).

Shanghai Stock Exchange (SSE) is the 5th largest stock market of the world in terms of market capitalization as recorded US$3.5 trillion in 2016, and 2nd largest in Asia. The Shanghai Stock Exchange is not entirely open to foreign investors because of rigid capital account controls worked out by the mainland authorities of China and more often directed by the decisions taken by the Central Government. In addition, the Shanghai Clearing House is responsible for providing security for the participants of the financial market, and carrying out effective clearing services development. Apart from that, it is also conductive to global peers' inter-agency cooperation and communication. It further provides central counterparty clearing of foreign currency in the interbank market, including settlement, clearing, collateral management, consulting services, margin management, information services, and correlated management division under other business.

The market conditions of China clearly indicate the necessity of some relevant policy adjustments for the purpose of making China's growth more sustainable. The past experience shows that making the transition towards a high income from a middle-income status can be much complicated as compared to moving up from low to middle income status. China is one of the densest populated countries of the world with more than 1.45 billion people. With the help of its ongoing economic development and reforms, China has successfully bypassed Japan as the second largest economy of the world since 2010 and overtaken the United States as the largest trading nation of the world in goods since 2012. As the second-leading importer and leading exporter globally, China is turning out to be the most imperative trade partner for several countries around the globe and starts to play an influential and important role in the international economy. With these economic strengths China is becoming the favorite place for international investors (Yao, 2014).

1.4 Research Problem

The stock market of China has evolved after the financial crisis of 2008. The role of bond market has been more enhanced in the past few years after the economic crisis. The amount of non-tradable government bonds has risen gradually; consequently, government bond market is experiencing fragmentation. In this scenario, different kinds of investors are constrained to trading in dissimilar trading markets, resulting in insufficient liquidity. Since all issued bonds are based on fixed interest bonds and the interest rate on bonds has increased as compared to the bank deposits interest rate, a burden of interest has been created which further amplifies the difficulty for the Chinese government to perform effective macro management of their economy (Zhang, et al. 2015). In addition, this factor has further disturbed the normal bond market operation. It seems that there is a necessity of inquiring about the relationship between stock and bond market.

1.5 Research Objective

The objective of this research is to explore the nature and the dynamics between bond market and stock market returns from the Chinese perspective.

For that purpose we will first identify macro economical factors influencing their relationship.

Then, we will develop a succinct and thorough view of the evolution faced by the stock and bond markets of China after the 2008 financial crisis.

By exploring the nature and the dynamics between bond and market stock returns we aim:

- To explore the correlation between stock market and bond market of China
- To explore the main drivers of this correlation
- To analyze the evolution of stock market after the financial crisis of 2008
- To explore the benefits that investors can withdraw from portfolio diversification

In this way, the research aims to identify and analyze some macro economical factors influencing the relationship. After analyzing these factors, the research aims to develop a succinct and thorough view of the evolution faced by the stock and bond markets of China after the 2008 financial crisis.

While keeping this aim, the researcher intends to meet the following objectives:

- To explore the correlation between stock market and bond market of China
- To explore the main drivers of this correlation
- To analyze the evolution of stock market after the financial crisis of 2008
- To explore the benefits that investors can withdraw from portfolio diversification

1.6 Research Questions

The study is based on the following research questions:

- What sorts of conditional correlation exist between the stock and bond returns in China?
- What are the main drivers of the dynamic correlation?
- How does the stock-bond returns correlation evolve during financial crises?
- How can investors benefit from portfolio diversification?

In order to answer the questions three hypotheses will be developed and tested.

- The first hypothesis for this study is, that there is time varying conditional correlation between stock and bond return in China.
- The second hypothesis states that stock-bond returns correlation is negative during financial crises and evidenced flight-to-safety phenomenon.
- The third hypothesis postulates that the correlation between stock and government bond returns is time-varying due to econometric and economic factors.

1.7 Purpose of the Study

There are a lot of research studies in which China's stock and bond markets development has been reviewed. Some authors have investigated stock market efficiency of China since 1994. With this, they have mostly emphasized on one particular factor of the market, for example, the segmentation into B-shares and A-shares effective market hypothesis. Likewise, some researchers have focused on the relationship between the economic development and stock market. For example, Laurenceson and Rodgers (2010) evaluated determining indicators of the contribution of the stock market to business financing; macroeconomic channels to development and corporate governance effects. At the same time, these researchers have admitted that data available was too constrained to conduct the research without limitations. While considering the limitations of previous researches, the current research has adopted a different route.

The current research therefore covers a detailed sketch of the relationship between bond market and stock market returns. Even if China is one of the countries least affected by this economic crunch, these events have totally changed the nature of the Chinese stock market. It would be safe to state that the stock market has been impacted by the financial crisis of 2008

(Zhang, et al. 2015). In this situation, it is much necessary to review bond and stock markets, as well as factors that persuade their performance. This study will therefore provide insights on the correlation dynamics between stocks and bonds in China for diversification in the context of dynamic asset allocation.

Chapter 2: Literature Review

2.1 Relationship between Bond and Stock

Explaining the association between bonds and stocks, Fama et al. (1993) state that when the economy rate is slow, consumers buy less and stock prices fall along with the profit of the consumers. At such a time when the economy is in recession, steady interest payments are guaranteed by bonds and investors invest more in bonds. The authors also explain that, in certain situations, both the bonds and the stock value increases at the same time. This is because there is too much liquidity or money chasing too few investments. This is also the case when the speculation is that the economy is moving towards recovery period and the investors optimistically buy stocks, while those pessimistic regarding the future of the economy buy bonds. The authors also state that there is a situation when both the bonds and stock prices fall. This is due to the fact that the investors are selling everything as they are in a state of panic.

In the meanwhile, defining the correlation between bonds and the interest rates, Kovalovet al. (2008) are of the view that an investment that is bought up front by an investor, and which then pays a fixed amount in return at regular time periods is called a bond. This means that, as the interest rate falls, the price of bonds increases. Therefore, there is an inverse relationship between interest rates and the market price of fixed government bonds. The authors believe that each individual had their opinion on what is the “average” rate of interest. If the market interest rate is above the average rate, then it would be rational to expect it to fall, and vice versa. When interest rates are high, individuals would expect the rate of interest to fall, and the price of bonds to rise. Therefore, to speculatively benefit from this, they should use their speculative balance of money to buy bonds. The speculative money balance is low when interest rates are high. When interest rates are low, individuals would expect the rate of interest to rise, and the price of bonds to fall. Therefore to avoid the losses involved with a fall in the price of bonds, individuals would sell their bonds, thus increasing the balance of speculative cash. The speculative money balance is high when interest rates are low.

Siegel et al. (2002) explain the importance and the use of the stock exchange market. There are thousands of financial instruments that have been issued; a stock exchange is where buyers and sellers interact. Each corporation is listed on different exchanges, meaning that it will publish the live prices that are being paid for the stocks. The authors also define the different types of shares that are traded on the stock market. There are two different types of shares that are traded on stock exchanges, and they differ in their characteristics. Firstly, the common stock is an instrument issued by companies that can be obtained via the primary or secondary market. Investment in the business means part-ownership of the company, and also rights and privileges, like voting power, and the ability to hold a position. An investor in debt is entitled to interest payments; the equity holder may or may not be paid dividends, depending on the company's policy. There is a high risk factor involved, as the price of the stock can fluctuate greatly. Holders of the instrument rank at the bottom of the scale if the company was to go into liquidation. Secondly, preference shares are an instrument issued by companies that rank higher than common stock in terms of scale of preference. They possess the same characteristics as equity in that its value is based upon the share's price fluctuating. However it also acts similar to a debt instrument, in that dividend is fixed, and the holder does not hold any voting rights.

2.2 Risks and Risk Management Associated with Bonds and Stock

Power (2008) highlights the importance of risk management and how risk management is necessary for investors when buying stocks. Risk management is not a single activity or a procedure; it is rather a series of activities that is more like a process affecting all the parts of the organization. Furthermore, it is a continuous process and repeated implementation brings constant improvements. The management for risk occurs anytime a fund manager or investor attempts to quantify and analyze the potential losses and takes the necessary action as per the risk tolerance and investment objectives. Improper and inadequate management for risk can cause many severe problems for individuals and companies. An example is the 2008 recession that was caused mainly because of the loose credit risk management caused by financial firms.

Saunders et al. (2006) explain that risk management is divided into two parts and how risk management is correlated with bonds and the stock market. Risk management can be divided in two steps; determining the kinds of risks that exist and then tackling those risks suitably as per the investment objectives of the company. Risk management is necessary and important in the financial world. It takes place when a fund manager hedges currency exposure with derivatives or when an investor buys government bonds over corporate debt as bonds have low risks. Another example is when the bank, before issuing a line of credit, performs a credit check to ensure that the individual will be able to pay off the loan. The authors define that risk management is highly important for businesses and individual investors as it minimizes the possibilities of occurrence of risk and also lays a plan for business to eliminate the risk and tackle it if it occurs. It is important to design a business impact analysis and a risk management plan as they help individuals and businesses understand the potential risks that a business can incur and the ways to reduce that risk. Types of risks differ from business to business and industry to industry but preparing a plan is a common process, as it highlights the different risks, how they can arise and the ways to tackle the risks. The risk management process is extremely important as it saves the businesses and individuals from heavy future losses. The more effective the risk management process, the less are the chances of risk occurrence.

McNeil et al. (2015) explain that risk management must be assessed so that risk is minimized and evaluated. The researchers further assert that the risk analysis process has four steps. Firstly, identifying the risk, that is brainstorming and reviewing all possible risk sources and the potential risks are identified. Secondly, assessing the risk, that is using the traditional problem solving methods to ensure that the risk is identified and minimized. It is important to identify the root causes of the risks and to highlight the reasons that would cause it and how it will impact the project. Thirdly, developing responses to the risk that is analyzing and evaluating the possible remedies and solutions to manage the possibility of the risk and to minimize its impact and prevent its hazard. Lastly, developing preventive measures or a contingency plan for the risk is important. This is the most important step as it ensures that there is a plan to tackle the risk before its occurrence. Furthermore, even if the risk occurs, the risk is identified and minimized and thus eliminated before it causes a major issue. Risk management is extremely important and, by employing the necessary steps, risk can be identified, minimized and eliminated.

Crouhy et al. (2000) explains that, in their study, credit risk is most associated with the bonds. They state that credit risk is one of the key risks that financial institutions are exposed to. The recent financial crisis revealed that the risk management procedure of financial institutions are inadequate and the majority of the losses occurred as parties failed to deliver their payment. During the times of a recession, credit risk becomes an even major concern as it increases the probability that parties will default on their payments. The law for credit risk is that the higher the risk, the higher rate of interest will be charged by the investors lending the capital. This risk is calculated on the ability of the borrower to repay the loan. The calculation for risk includes revenue generating ability of the borrower, collateral assets and the taxing authority. Many factors influence the credit risk of an issuer. Examples include rising interest rates, falling cash flow from operations or adverse market changes. The stability and regulatory practices of its government and the country's sociopolitical situation is included in the credit risk associated with bonds. One of the most fundamental types of risk is the credit risk as it represents the chance that the investor might lose their investment. Except for the bonds issued by the government, all other bonds carry a credit risk also. The authors explain that an investor is purchasing a debt certificate when he/she purchases a bond. That is like the borrowed money that has to be repaid over a period of time with interest. The authors explain that many investors fail to realize that corporate bonds, unlike government bonds, are not guaranteed by credit and full faith.

Market risk is highly associated with the stock market; Alexander (2001) explains market risk and the risks that can arise with concern to the stock market. Market risk is the risk of loss as a consequence of the changes in the market dynamics. This can include factors such as changes in interest rates, exchange rates, stock market prices or any other external factor that has a bearing on the operations of the organization. Market risk is unpredictable and beyond organizational control and, therefore, it is more difficult to predict and counteract. The two major types of risks are specific risks and market risks. Unsystematic risk or specific risk is directly tied to the security's performance and can be protected against with the aid of investment diversification. Example of unsystematic risk is that an individual owns the shares of a company which declares itself bankrupt, thus making all the shares worthless. The author also explains that there are four types of market risk. Firstly, equity risk which is the risk that the share prices might change. Secondly, interest rate risk, connected to the fact that interest rates will change.

The risk that foreign exchange rates will change is known as currency risk. Lastly, the risk that commodity prices will change is known as commodity risk.

Liquidity risk is also linked to bonds and has a negative effect on the bonds. In this regard, Pastor et al. (2001) describe the risk stemming from the lack of the marketability of an investment that is neither being bought nor sold fast enough to minimize or prevent loss, known as liquidity risk. It is typically reflected in large price movements or unusually wide bid-ask spreads. The larger the liquidity risk, the smaller is the size of the issuer or its security. The risk usually arises when an individual or a business requires immediate cash and holds a valuable asset that is not able to sell or trade at market value due to an inefficient market or due to lack of buyers. While purchasing a long term asset, it is necessary to take into account the selling ability of the assets while considering their own short term cash needs. Due to the nature of the market being illiquid, assets are difficult to sell and carry a high liquidity risk as they cannot be sold easily for cash. Due to increased potential of capital loss, liquidity risk lowers the value of businesses and certain assets. Unlike government bonds, corporate bonds do not always have a ready market. Due to a thin market, there is always a risk that the bond holder may not be able to sell his corporate bonds as there are very few sellers and buyers for this type of bond. In a particular bond issue, low interest can lead to substantial price volatility and have a negative impact on the total return of the bondholder. The authors explain that the investor is forced to sell the bond at a much lower price due to the thin market.

Another risk associated with bonds is explained by Evans et al. (1998). The authors explain that inflation risk is very common with bonds. The investor commits to receiving a rate of return when he buys a bond. The return on the bond can either be variable or fixed for as long as the bond is held by the investor. The authors also explain that a question arises about what will happen in the circumstance that the inflation and the cost of living increases suddenly with a higher rate compared to the income statement. The authors clarify that in such a situation, the investors will suffer from a negative exchange rate and their purchasing power will erode. The authors also give an example that an investor is receiving a rate of 3% on a bond. If the inflation increases to 4% after buying the bond, the rate of return of the investor would be -1%.

2.3 Portfolio Diversification and the dynamic stock-bond correlation in the asset allocation

Diversification is a risk management technique that involves the accumulation of a variety of investments (e.g. stock, bonds, treasury bills etc) often in a bid to spread investment risks. Combined investment instruments that are held by an individual or a firm are referred to as portfolio or technically, investment portfolio. Portfolio diversification therefore refers to a risk management strategy aimed at keeping to the barest minimum overall risks associated with investment portfolio. The essence of investment portfolio management is to minimize risk and maximize investment returns.

Diversification has numerous advantages. An important advantage of diversification lies in its potential to help mitigate investment risks. Empirical studies have proven that diversification actually reduces risks in investment portfolio (Chou & Liao, 2008). In practical terms, diversification could be likened to a shock absorber in the event of volatility in investment risks and returns. Logical links exist between the concept of safety and the principle of diversification. In other words, diversification works to provide safety nets against market volatility. Diversification, in spite of its numerous advantages, has to be done reasonably, as evidence has shown that over-diversification into various classes of assets or diversification into positively correlated assets could result in negative overall net return on portfolio investment

(Connolly, Stivers, & Sun, 2005) . Diversification and portfolio risk management are often carried out within the confine of established theories. These theories therefore become benchmarks guiding portfolio risk management.

Markowitz (1952) pioneered the 'mean variance portfolio theory' that serves as cornerstone for many other theories aimed at finding the optimum portfolio that balances risk and return. The fundamental assumption of the mean variance portfolio theory is that diversification can lead to reduced risk; particularly international diversification. The following two-asset portfolio variance equation illustrates this:

$$\sigma^2 p = \omega_1^2\sigma_1^2 + \omega_2^2\sigma_2^2 + 2\omega_1\omega_2\rho_{12}\sigma_1\sigma_2$$

ω_1 and ω_2 represent the portfolio weights of both assets. $\rho 12$ designates the correlation between the two assets. In the case of this thesis, the SSE stocks and the 10 year Government bonds are the considered assets. A direct implication of this formula is that the correlation between assets is crucial for diversification purposes. In fact, when assets are imperfectly correlated ($\rho_{12} < 1$), a portfolio's expected volatility can be decreased without a meaningful impact on the expected return. The drawback of the model is that it often becomes complex to manage when large portfolio assets are involved. He also introduced the Efficient Frontier Model which holds that it is more efficient to chose portfolio that maximizes returns for a given level of risk or in technical parlance, that lie on the efficient frontier than choosing security individually.

Another portfolio risk management model is the Single Index Model (SIM), also developed by Sharpe (1963). The highlight of the model is that it advocates for correlation of each security with index of all securities included in a given analysis, rather than estimating every pair of securities. This approach to correlation substantially reduces the number of required inputs when analyzing portfolio risks. Capital Asset Pricing Model (CAPM), also developed by

Sharpe (1964), is another prominent portfolio risk management theory. The theory builds on the SIM model. The fundamental difference between the two theories is that, while SIM advocates correlation of each security with index of all security included in an analysis, the CAPM rather requires correlating each security with 'efficient market value' of weighted portfolios in market (universe). This model recognizes the effect of global security market and favours standardization of investment decision. Arbitrage Pricing Theory (APT) was developed by Rose (1976) as a portfolio risk management theory. It is a modification to the CAPM theory. The theory proposes correlating each security with various market values (e.g inflation, interest rate etc) rather than a single one.

Whatever theory is adopted in portfolio risk management, risk and return remain important determinants of investment choices. Decision to make, retain or transfer investment in any financial instrument stems primarily from perception (often based on sound empirical judgments) of risks and returns inherent in such decision. Armed with this truism, one would expect predictable linear tradeoffs between risk and return on a particular investment choice but practical experience and empirical studies have proven otherwise. The uncertainty that characterizes establishing, *ab initio*, values of these two important variables in an investment drive, often compel investors to embrace diversification as an investment and risk management strategy (Philips, Walker, & Kinniry, 2012). Diversification could occur within and across asset classes (Flavin, Hurley and Rousseau, 2002). It often leads to the emergence of investment portfolios with combinations of stocks and bonds. Stocks and bonds are established as primary investment instruments in investment bundle of a typical investor (Chou & Liao, 2008), deserving of thorough assessment to ensure optimal investment outcome.

The importance of stock and bond in investment portfolio prompted numerous studies over the years on stock and bond investment portfolio management, with series of debates unearthing divergence and convergence views, arguments and submissions on the subject matter. Prominent among these debates is the stock-bond correlation for asset allocation. Stock-bond returns correlation, according to Chou & Liao (2008), plays an important role in cross-market hedging, asset allocation, and risk diversification.

Studies have examined co-movement of returns on stock and bond by computing coefficient of correlation with a view to understanding the implications of investment or divestment in instruments in relative terms and determining optimal asset allocation to the alternative investment. In fact, Philips et al. (2012) posited that when 'thinking about portfolio diversification, investors instinctively focus on correlation'. Corroborating this assertion, Flavin *et al.* (2002) argued that "in terms of risk reduction, the coefficient of correlation is the most important input into any asset allocation model". Correlation models are usually based on historical data on asset movements.

In stock-bond co-movement assessment, correlation has been modeled as a constant and unconditional variable. Constant research in the field of financial asset management has brought to knowledge that time plays a crucial role in observed correlations between financial assets (Longin and Solnik, 1995). To address the time variability factor in correlations, variants of dynamic correlation were developed, including the popular Autoregressive conditional heteroskedasticity (ARCH) and Generalized Autoregressive conditional heteroskedasticity (GARCH models and their variants. Primarily, therefore, the importance of dynamic correlation model stems from its ability to factor in time variability. Time variations in stock-bond return correlations have profound implications for asset allocation and risk management (Ohmi & Okimoto, 2016).

2.4 Drivers of the correlation between stock and bond markets

Nystedt (2004) defines the drivers of the correlation between stock and bond markets. The derivatives market is where a variety of derivative instruments are traded. The author explains that a derivative is an instrument whose price is dependent on one or more underlying asset(s). It is merely a contract between two parties. Changes in the underlying asset(s) can cause great fluctuations in the price of the derivative. Like money and capital markets, they are traded with investment banks usually acting as the intermediaries between those looking to raise liquidity, and those looking to invest. The author illustrates the two main ways that derivatives can be traded and how they are linked with bonds. Derivatives can be traded in two ways; on an exchange and over the counter (OTC). Firstly, the conditions for establishing and trading an OTC derivative are less strict than exchange traded derivatives (ETDs). The issue and trade of each instrument is on an individual basis, meaning a financial intermediary (usually investment bank) will 'make a market' between buyers and sellers. This gives greater flexibility with regard to the terms of the deal. However the level of risk is much higher as counter parties can be affected if the trade loses too much money. The author enlightens that a derivative must meet certain strict criteria to be traded on an exchange market. There are variables (maturity length, credit rating, etc.) that can be controlled to allow a derivative to be traded on same market. The fact that these two positions are equaled off means the overall risk is reduced if the underlying price moves drastically. Performing the trade through an official exchange also reduces the level of counterparty risk, as trades are done through a clearing house.

Suntherland (1996) defines the financial market and explains how the stock exchange plays a role in the financial market. Financial markets exist to bring together lenders (investors) with borrowers (governments and companies). It is often the case that the borrower is looking to raise money in order to undertake some level of investment. An investment bank will often act as an intermediary in the process. The term financial markets encapsulates the trading of different financial instruments, on various terms, all in order to find a solution that works for both parties. Money markets act as any other market, bringing together buyers and sellers of a specific tradable good. Rather than being shoes, or books, the instruments that are being sold are referred to as short term. The author defines that the money market is a subsection of the wider fixed income market. It is used by large institutions to finance short term cash needs. Examples of these are governments, mutual funds, and other organizations with high financial backing. The sums of money that are used on the money market are of such a high amount, that individual investors cannot usually access it. They must do so through a mutual fund.

Bolton et al. (2000) explain that on the capital markets, there are a number of different instruments that can be bought or sold. These broadly fit into two categories: debt and equity. Debt is a corporation issuing an agreement to repay a certain sum at a later date, and equity is selling rights of ownership in the company. There a number of the financial instruments listed above that are traded. The authors also define sovereign bonds, explaining that a government is looking to fund a large, long-term infrastructure project and is looking to raise funds through the capital markets. It issues sovereign bonds, which are then purchased by investors. This means that the government gets the funds that it requires upfront, and is able to finance the project. Investors then are able to claim back their nominal amount at the maturity date. The bonds belong to the investor, and they can keep them, or trade them on the secondary market.

Guo and Brooks, (2008) asserts that China's stock market has transformed from a planned economy to a market economy in the transition process of recovery. The Chinese stock market aims to function in the process of economic restructuring with special needs. In this transition, economic reform has largely taken place to encourage income distribution pattern. After the experience of the financial crisis of 2008, the government of China started to carry out the investment and financing system innovation test. On the one hand through issuing bonds to raise funds from the community of nation-building, on the other hand to encourage and support joint-stock market. Therefore, the use of mobilization for economic development function of the stock market was transformed to raise funds in China. As China's securities market has a state-owned enterprise financing pressure, there can only be finance market institutional arrangements, and the stock market has a mature market economy belonging to the institutional arrangements of the investment market. The same research study explains that the initial system of financing arrangements for the Chinese market, the stock market has brought a number of defects.

Moreover, while talking about the other drivers of correlation between stock and bond markets, Garrett, (2010) explains that stock trading behavior and process is unique and based on specific performance. Although, since 2001, China's securities issuing and listing approval system has been changed from the traditional approval system. In addition, market segmentation is particularity depending on the investment body, the presence of state-owned shares, legal person shares, individual shares and foreign shares. Prior to the financial crisis of 2008, the A-share and B-share were artificially divided subscribers, which were reducing the market's organizational effectiveness. Along with that, the special nature of the stock pricing has also changed. In the specification mature securities market, the price of newly listed securities is based on their intrinsic value judgments formed by supply and demand; supply and demand determine equilibrium price (Ng, 2011). An initial public offering (IPO) is the initial stock sale by a private organization to the public. Initial public offerings are more often issued by younger and smaller organizations seeking the resources to get bigger, but can also be carried out by privately owned large organizations looking to become openly traded. In an IPO, the issuer obtains the assistance of an underwriting firm, which helps it determine what type of security to issue (common or preferred), the best offering price and the time to bring it to market. It is a step forward in China's stock issuance of market-oriented reform.

Hence, the researchers have admitted the fact that the financial crisis of 2008 has evolved the nature of stock market in China. The integration and increased participation of bond market with stock market returns have made the financial system of China, to some extent, secure from future financial crises.

2.5 Summary

In short, more often stocks have an inverse relationship with the bond prices and they both move in opposite directions. Bonds prices go down when the stock value goes up. This is because when the economy is booming, the stocks do well. Companies receive higher earnings as consumers are buying more stock and the demand for stock increases. Sometimes, investors also sell their bonds and buy stocks as they want to benefit from the increasing stock prices. Furthermore, in some conditions, there are different types of risks associated with bonds, like liquidity risk, inflation risk and market risk. More specifically, the review of the literature focuses on the evolution experienced by Chinese stock market after the 2008 financial crisis. The review of the literature has presented research findings of different researchers who, all together, acknowledge that, after the 2008 financial crisis, the correlation between stock and bond markets have been strengthened. In addition, the understanding gained from this chapter is utilized and elaborated in the subsequent chapters of the research.

Chapter 3: Stock and Bond Markets

3.1 Chinese Stock Market

The stock market is the transfer of shares that have been issued and the sale and distribution of places, including the exchange market and the OTC market, two broad categories of stock market. It is built on the basis of the distribution market, so-called secondary market. Structure and trading activities in the stock market are more complex than those of the issue market (primary market), its role and influence is greater. Stock market speculators and investors are thermometers of economic and financial activity. The negative phenomena such as the stock market short selling of stock, etc., can lead to market crash and other hazards. The only constant in the stock market is that it is always changing (Cai, 2014).

'China has two trading markets, Shanghai Stock Exchange (SSE) and Shenzhen Stock (SZSE) Exchange (Chang, Luo, Shi, & Zhang, 2013). This thesis will essentially focus on the Shanghai stock exchange. The securities listed at the Shanghai stock market are based on three major categories of bonds, funds and stocks. Bonds traded on Shanghai Stock Exchange include treasury, convertible corporate bonds and corporate bonds. The T-bond market of the SSE is the most active one in China. In addition, there are two kinds of stocks commonly issued in the SSE: "B" shares and "A" shares. "A" shares are priced in the local currency, while B shares are quoted in United States dollars. In the initial phase, trading in "A" shares are limited only to local investors and B shares are obtainable to both foreign and domestic investors. Though, after implementation of 2002 reforms, foreign investors are now allowed to trade in "A" shares under the Qualified Foreign Institutional Investor program (QFI), which was legitimately launched in 2003. At present, around 98 foreign investors have been acknowledged to sell and buy "A" shares under the Qualified Foreign Institutional Investor program (Hussain et al., 2015).

3.1.1 China's Stock market evolution after financial crisis of 2008

According to Zhang et al., (2013) while the international financial crisis that began in the year 2007 provoked recessions in several western countries, the growth of China remained relatively robust regardless of the damage to many of the main export markets of the country. Domestic demand in China was increased by an enormous fiscal stimulus package of around $600 billion in 2008 that is equivalent to 20% of the overall GDP. The value of bond market started to be acknowledged by the Chinese economic experts. Certainly, by the year 2009, concerns moved toward passing up inflationary pressures. In showing resistance to external pressures to let enhanced flexibility, the officials of Chinese economy encouraged the integration of bond market and stock market returns (Kong, 2012). On the other hand, according to Warner, (2015), since China was and, to a degree, still is a predominantly planned economy; the excessive control of government is the most conspicuous custom. The major changes in the financial system of China have been taking place after the drastic financial crisis of 2008. However, since 1990 up till now, several regulatory changes have taken place that reduced barriers to trade and enhanced the legal framework. For example, the stamp tax, which seller and buyer have to pay for every transaction, was reduced several times. Diminishing transaction costs must have stirred trading. The government interventions like the ban of unlawful futures trading, though, could have overshadowed other improvements. The overall impact of these regulatory changes is unclear and demands elucidation to further stimulate helpful economic reforms.

The research conducted by Song (2015) shows that the current financial system of China is influenced by a huge banking sector. It is no denying to the fact that the banking system encourages the influence of bond market. In recent years, banks have made substantial progress in mitigating the minimizing of the ratio of non-performing loans and improving their effectiveness. Prior to the 2008 financial crisis, the role of Chinese stock market in the allocation of resources in the financial system has remained ineffective and limited. After the economic crunch, the economic experts of China have realized that further development of Chinese stock market and bond market is the most imperative task in the long-run. According to the research conducted by Ding (2000), the most booming part of the country's economy, in terms of assisting the overall economy growth, is a substandard sector that is based on unconventional financing channels, institutions and governance mechanisms. Bhattacharya, (2014.), on the other hand, explained that after the experience of the 2008 financial crisis, the Chinese financial system has shown coexistence with banks and their bond for the purpose of sustaining support to industrial sector. The research further concludes that the evolution in the stock market has paved the way for making the Chinese financial system more secure from future crises such as a real estate or stock market crash, banking sector crisis, and a "twin crisis" in the banking sector and currency market.

3.1.2 The Shanghai Stock Exchange Composite Index

The Shanghai Stock Exchange Composite Index is a capitalization-weighted index. On daily basis, the index tracks the price performance of all B-shares and A-shares scheduled on the Shanghai Stock Exchange. The Shanghai Stock Exchange Composite Index was introduced on the 19thof December 1990 with a 100 base value. The trade volume in Index on Q is scaled down by a factor of 1000.A market composite is composed of all the A and B shares that are traded on the Shanghai Stock Exchange (SSE). The composite index is calculated by using a base period of 100 (Kong, 2012).

The figure of composite index can be calculated by using the formula given below:

$$\text{Current Index} = \frac{\text{Market Cap of Composite Members}}{\text{Base Period}} \times \text{Base Value}$$

A composite is a grouping of indices, equities, or other factors that combined in a consistent way, provides a helpful statistical measure of a large sector or market performance in due course. It is also known as "composite index". The SSE Composite is an effective way to get an extensive performance overview of listed companies in the Shanghai Stock exchange. The SSE 50 Index and SSE 180 Index are more selective indexes that indicate the market leaders by market capitalization. It has become more probable over time that the SSE Composite will reflect the entire China's economy; yet there are still many state-run large companies that have to go public in different sectors such as energy, healthcare and banking (Wan et al., 2014).

These indexes are helpful tools to measure and track changes in price level of an entire stock market. As a result, they offer a useful standard against which to gauge portfolio of an investor. The main objective of a well-diversified portfolio is to do better than the main composite (Wan et al., 2014).

As of January 2008, 904 companies were listed on the SSE with the total market capitalization of SSE reached RMB 27.533 billion (US$3,241.8 billion; US$1 = RMB 6.82). The SSE was composed of 850 listed companies in the A-share market and 54 listed companies B-share market, which accounted respectively for 99,5% and 0,05% of the market value capitalization. In January 2016, 1073 companies were listed in the A-shares for a market capitalization of RMB 24.960 billion and 52 companies were listed in the B-shares for a market capitalization of RMB 117 billion. The total SSE market was composed of 1125 companies with a total market capitalization of RMB 27.505 billion.[1]

3.2 Chinese Bond Market

In recent years, China's bond market has rapidly developed. The effective implementation of monetary policy to provide the necessary conditions for the sound operation of the financial system has made a tremendous contribution. However, the long history of the country for financial system reforms also contributed a lot in making China's bond market strong and sustainable. The development is still ongoing and has much to improve. China has two major bond markets:- the exchange market and the interbank market – Shenzhen Stock Exchange and Shanghai Stock Exchange. The Chinese interbank market is driven by quote over-the-counter (OTC) controlled by China's central bank, the People's Bank of China, where negotiations of deals between two different counterparties take place via an electronic trading system. On the other hand, the Chinese exchange market, controlled by the CSRC (China Securities Regulatory Commission), is a retail market, in which individual and small- and medium-size institutional investors carry out trading through concentrated matchmaking method Chan, Menkveld, & Yang, 2007).

The Chinese interbank bond market was introduced in 1997 and has turned out to be China's most active bond market, almost absorbing 97 percent of the trading activity in the year 2013. Major investors in the Chinese market are commercial banks, asset management companies, insurance companies, securities houses, finance companies, and other institutional investors in China. In general, the Mainland bond markets are closed to foreign investors, except for (QFIIs) Qualified Foreign Institutional Investors in the exchange markets.

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[1]http://www.hkex.com.hk/eng/csm/highlightsearch.asp?LangCode=en&TDD=1&TMM=2&TYYYY=2006&x=39&y=6

Major interest rate based products are treasury bonds, central bank papers and policy financial bonds. Policy financial bonds and Central bank papers are traded exclusively in the interbank market. Main credit products include medium-term notes (MTNs) and commercial papers (CPs) that are issued by local organizations, enterprise bonds issued by state-owned enterprises, convertibles bonds and corporate bonds issued by scheduled companies and monetary bonds issued by economic institutions. Enterprise bonds in the bond market of China are the corporate bonds which are assured by the Central banks, thus their coupon rates are below the corporate bonds with similar maturity. Their maturity in the bond market tends to be from middle to long-term (Wan et al., 2014).

3.3 Factors affecting the stock-bond correlation

The relationship between stocks and bonds has been weak over the past forty years. The two factors relationship history has it that they have been moving in the opposite direction. However, this traditional stock-bond relationship is beginning to change. Stocks and bonds returns have a little positive correlation. There are various macro-economic factors that affect the two long-term assets. This essay will discuss industrial production index, money supply, SHIBOR, inflation rate, consumer confidence, business cycle, FX rate, International reserves and balance of trade as the macro-economic variables that influence stocks and bonds.

3.3.1 Industrial production index

Industrial production index (IPI) is an economic indicator that is published to measure real output in manufacturing, utilities and mining. This index is an alternative to GDP. The industrial production indices are normally calculated as Fisher indices. Weights are attached to each to estimate the value added. This factor is a major indicator of economic growth and it can be used to determine the potential of an economy. The output gap reflects information about the real term structure of interest rates. Therefore, this factor has the potential to affect both equity and bond prices in the same manner. Studies have shown that there is a slight positive correlation between this factor and the stock and bonds returns. This is an important macro-economic factor that should be focused on in the analysis of stocks and government bond returns because it is a major economic driver and it is positively correlated to stock and bond returns (Li, et al., 2015).

3.3.2 Money Supply

Money supply, also known as money stock is the amount of total monetary assets that are in circulation within an economy at a specific time. Data relating to money supply is stored by the central bank of the country and also economic analysts can access the information for their use. Money supply has a great impact on various economic factors. It is the one that is responsible for price changes and inflation rates. Besides, exchange rates and business cycles greatly depend on the money supply. This shows that the economy to a large extent is influenced by the amount of money circulating in such an economy. The relationship between money supply and prices is contained in the quantity of money theory (Perego & Vermeulen, 2016). A monetary policy is the one that is responsible for money supply. It consists of a combination of actions by the central bank and other regulatory bodies which determine the rate at which money is circulated in an economy. Some of the monetary policy actions include the increase of interest rates, sale of government bonds and regulation of the amount of money held by banks. The money supply factor has a negative correlation with the stock and bond returns. This is so because, whenever an economy allows more money to circulate, the purchasing power increases and many people invest more in stocks that don't yield more returns. This also applies to bonds;

they lose value due to availability of funds to purchase them hence the rate of return may be affected negatively (Baxter & Crucini, 1995).

3.3.3 Balance of Trade

Balance of trade is the difference in value between a country's imports and exports. This phenomenon is also referred to as balance of payments (Lavoie, 2015). When a country spends more on imports than it earns from exports, it threatens such an economy if balances are not found. A bond will not perform well if the economy depends on imports since they will be spending more on such imports yet foreign earnings are supposed to cut on the import costs. This affects the performance of the financial assets.

3.3.4 The Shanghai Interbank Offered Rate (SHIBOR)

The Shanghai Interbank Offered Rate is the rate at interbank lending rates in Shanghai China. These are the rates at which banks are comfortable to lend to other banks without security. Different rates apply here and they range from overnight lending to one year. These rates are determined by 18 banks in which a relative rate is developed depending on the existing lending rates. It is done by elimination of the two highest rates and the two lowest rates and averaging the remaining rates. Default risk is also taken into consideration of these rates. This increases this rate and thus affects the cost of overnight lending. SHIBOR is assumed to be the credit risk that the banks take to lend to each other since this lending does not require any form of security. Whenever there is an increase in the SHIBOR there will be an increase in the basic lending rates since it will signify insecurity and increased risk. This will lead to people investing in more risk free investments in which treasury bills and government bonds are included. Again, when the SHIBOR is lower, that means the banking sector is safe and people will be comfortable investing in the sector easing the treasury bills and government bonds. This factor has a negative impact on the stock and bond returns (Baxter & Crucini, 1995).

3.3.5 Inflation Rate

The most common definition of inflation is the general rise of prices in an economy. However, this increase in prices is what is referred to as price inflation. Monetary inflation is the expansion of credit in the financial markets. When there is more money in circulation, the commodity prices also increase and this is the effect called inflation. The government has mechanisms that it employs to balance the economy. When the inflation rate outgrows the rate of earnings that bonds earn interest, the investor has to be affected hence there is a negative correlation between the rate of inflation and the long-term assets which include stocks and bonds (Aslanidis & Christiansen, 2014).

3.3.6 Consumer Confidence

Consumer confidence is an economic measure that shows the level of consumer optimism and attitudes towards the economy and their personal financial status. Thus consumer confidence is one critical market indicator. When consumer confidence is high, consumption or purchases will be generally high. Consumer price index (CPI) is also affected by the inflation rate. It is calculated using this formula: Current item price*Base year price* Current CPI/Base year CPI. This factor has a positive correlation with the stock and bond returns (Perego & Vermeulen, 2016).

3.3.7 Business Cycle

Business cycles are important factors to consider in investment. Various studies have shown that business cycles have an impact on permanent asset's returns where stocks and bonds are included. Different business cycles affect the performance of assets because they are macro-economic phenomena that cannot be evaded by any form of investments. For instance, when there is an economic crunch, even the stocks and bonds will be affected and therefore there is a strong correlation between the business cycle and stock and bond returns (Baxter & Crucini, 1995).

3.3.8 Forex Rate

FOREX rate is the foreign exchange rate between different currencies. There is a relationship between the yield of the bonds, and the general trend of the currency: when people are willing to take risks, low-yielding currencies depreciate, as investors buy high yielding bonds and do not hedge the currency risk. The money supply factor has a negative correlation with the stock and bond returns. This is so because, whenever an economy allows more money to circulate, the purchasing power increases and many people invest more in stocks that do not yield more returns. When the local currency is weak and people will tend to invest in bonds which are less risky (Aslanidis & Christiansen, 2014).

3.3.9 International Reserves

International reserves are all kinds of reserves that can be passed to different countries' central banks (Aslanidis & Christiansen, 2014).These reserves come in handy in trying to rescue economies whose currencies are struggling. Such economies can draw from reserves like the international monetary fund to supplement their budget. This form of support is in form of a debt and when the interest rate of this debt is higher than the bond yield, investors may lose value of their investment and therefore the International reserves are negatively correlated to these assets' earnings (Aslanidis & Christiansen, 2014).

3.3.10 Economic policy uncertainty

Economic policy uncertainty is the prediction of the future trends of the economy. These trends are measured by the economic policy uncertainty index (Li, et al., 2016). This variable is important in the stock market because it can be used to predict the outcomes of a given economic factor. In businesses, uncertainties can be caused by different economic patterns. When an economy has unpredictable economic trends that show it is a risky environment for business. The economic policy uncertainty index is important in equity investment and risk management for investors. This is so because there is a correlation between the index and the stock market. During the periods of high economic policy uncertainty, investors sell their stocks and during periods of low uncertainty, they get more returns from their stocks. This shows that the economic policy uncertainty is negatively correlated to the stock returns.

3.3.11 Flight-to-safety

Flight to Safety in economics is the sudden increase in demand for safe assets. This is a preference for low risk, high quality (low default) and highly liquid assets by investors. More broadly, this is a phenomenon in which investors shift from risky assets and invest in assets that they consider to be safe. This normally happens during an economic turmoil (Beridze, 2008). When investors shift their investments in this manner, there is a probability of affecting the financial sector negatively. This is so because when people invest in safe assets, there is a likelihood of a sudden dry up of safe and liquid assets which will drive the economy into further shocks. Episodes of flight-to-safety are normally triggered by unusual and unexpected events in the economy.

Since flight-to-safety phenomenon implies a shift in investing behaviour towards some safe group of assets from risky assets, efforts to find evidence on flight-to-safety have been concentrated on analyzing widening yields or quantity changes between two assets. A number of studies find stronger negative association between stock and bond markets during a financial turmoil. Flight-to-safety is also observable within a safe group of assets (Holmes & National Research Council, 2011).

The effects of this kind of behavior in the economy are that the more the risky assets are avoided the more they will lose value. For instance, on an investor's balance sheet, there are risky assets and less risky assets. If the risky assets start losing value, the investor will liquidate them and retain the less risky assets. All other investors may follow this trend and remain with safe assets. The more this trend continues, the more the risky assets lose value. Therefore this behavior affects the value of stocks and people will tend to invest more in government treasury bills and bonds (Beridze, 2008).

Treasury bills and bonds are safe investments that may be having low returns but less risk. When investors liquidate their risky assets, they start investing in assets like bonds. This makes bonds to have a high value since they are in demand. The other effect of episodes of flight-to-safety is that investors find it difficult to get financing for risky assets. This creates a negative effect on the general economy since the financers will also lose business due to the risk involved in assets that have downward trends. Besides, there will be too much dependence on the bonds which are less risky which in turn may have lower returns. Flight-to-safety episodes are not healthy for the economy and there should be measures to reduce their effects in the economy (Roger, Vlček & International Monetary Fund, 2012).

To conclude, all these macro-economic factors play a vital role in the economy of a country and that is why monitoring them closely is important and that helps in determining where to invest. These factors are important because there is a little correlation with the performance of stocks and bonds. In some instances, they lose value due to availability of funds to purchase them hence the rate of return may be affected negatively and at times it can have a positive effect.

Chapter 4: Research Methodology

4.1 Research Design

The samples analyzed in this research include the Shanghai composite stock market index (SSE), the A-shares of the SSE index (SSE-A), the B-shares of the SSE index (SSE-B) and the 10-year Chinese Government bond returns.

The empirical analysis of the thesis is performed on a monthly frequency by averaging the daily data returns over a month period. The Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroscedasticity (DCC-GARCH) model, as described in the section 4.2, is used to estimate the time-varying correlations between China stock and government bond returns. The data of the Shanghai composite index (SSE), A-shares index (SSE-A) and B-shares index (SSE-B) prices were retrieved from Macrobond. The monthly stock returns are computed as ln(Pt/Pt-1), where Pt is the closing value of the index for the period t. After retrieving the bond yields (y) of the 10-year Chinese government bond on Macrobond, the bond returns can be determined as $R \approx -\Delta y$ (Iania, personal communication, 1st August 2015).

Since the conditional correlation of the stock and bond returns are to be estimated using the DCC-GARCH model, there cannot be missing values and, therefore, the time series are constructed starting from October 2007 – the earliest dates available for the B-shares index. As a result, the time period covered in this study is 8 years and 9 months: from October 1, 2007 until June 30, 2016.

Eleven macro-finance variables are selected according to the literature, the data and also their availability in order to measure their impact on the stock-bond return correlations. Table 1 below provides an overview of these variables. For stationary reasons, the original time series of all the variables are transformed into log differences (FX, EXP, IMP, RES, IPI, INFL, M2, CC, BC, EPU) or first differences (SHIBOR) for stationary reasons. These transformations are expressed in the third column 'definition' of Table 1. The fourth column reveals the original source of the data.

Table 1. Definition of the variables

Variables	**abbreviations**	**Definition**	**Source**
FX spot rates, CNY per USD	FX	Log difference of the FX spot rates.	Macrobond
ForeignTrade,Export, USD	EXP	Log difference of the Chinese exportation.	Macrobond
ForeignTrade,Import, USD	IMP	Log difference of the Chinese importation.	Macrobond
International Reserves, Foreign Exchange Reserves, USD	RES	Log difference of the International reserves.	Macrobond
SHIBOR	SHIBOR3	First difference of the Shanghai Interbank Offered Rate 3-month	Macrobond
Industrial production	IPI	Log difference of the industrial production index.	OECD
Inflation rate	INFL	Log difference of the CPPY=100 for all urban consumers.	Macrobond
Money Supply, M2	M2	Log difference of the change in M2	Macrobond
Consumer confidence index	CC	Log difference of level consumer confidence index	Macrobond
Business cycle signal	BC	Log difference of level BC index	Macrobond
Economic Policy Uncertainty index	EPU	Log difference of level EPU index	Macrobond

4.2 The Multivariate DCC-GARCH model

The DCC GARCH model is an extended form of the univariate GARCH model which avoids all sorts of complexity of the conventional multivariate GARCH model (MGARCH). This model developed by Engle (2002), suggests that the stock-bond conditional correlation is time-varying. The estimation of the DCC model involves a 2-step procedure where we first estimate the variance equation using the mean equation of each asset in an univariate GARCH model and then generalize variance-covariance matrix using the estimates derived in stage one in order to obtain the estimation of the correlation among the series. This MGARCH model has the potential to perform an estimation even in extremely large correlation matrices, since the correlation estimation process is independent of the number of assets.

The DCC-GARCH model can be then specified as follows :

$$rt = \mu t + a_t \ (1)$$

rt: column vector of log returns for n assets at time t.
at: column vector of mean-corrected returns of n assets at time t.

$a_t = H_t^{1/2}\epsilon_t \sim N(0, H_t)$, $E(a_t) = 0$ and $Cov(a_t) = Ht$

μt: column vector of the expected value of the conditional rt.
$H_t^{1/2:}$ Any square matrix at time t ensuring that H_t is the conditional variance matrix of at
ϵ_t = column vector of independent and identically distributed errors such that the expected value of ϵ_t is equal to 0 and the expected value of ϵ_t multiplied by its transposed is equal to the identity matrix

The conditional covariance-variance matrix of at at time t, H_t can decomposed as:

$$\boldsymbol{H_t \equiv D_t R_t D_t} \ \mathbf{(2)}$$

Where $\boldsymbol{D_t} =$ **diag** $\{\sqrt{\boldsymbol{h_{i,t}}}\}$ represents a nxn diagonal matrix of the conditional volatility of returns on each assets with $\{\sqrt{\boldsymbol{h_{i,t}}}\}$ or in other words the conditional standard deviations of at at time t. $\boldsymbol{D}$t is positive definite since all its diagonal elements are positive due to the square roots. The expressions for $\boldsymbol{h}$ are the time-varying standard deviations from the univariate GARCH model;

$h_{i,t} = \omega_i + \sum_{q=1}^{Qi} \alpha_{iq} \alpha^2_{i,t-q} + \sum_{p=1}^{Pi} \beta_{ip} h_{i,t-p}$ *where* $\alpha_i \geq 0$, $\beta_i \geq 0$, $\alpha_i + \beta_i < 1$.

The univariate GARCH models can have various orders GARCH(p,q), where p represents the autoregressive lag order or ARCH term ($\alpha^2_{i,t-q}$) and q represents the moving average lag order or GARCH term ($h_{i,t-p}$). According to Engle and Colacito (2006), GARCH(1,1) is adequate for the estimation of the stock-bond return correlations. Commonly, the univariate GARCH models are referred to as the variance equations.

R_t represents the conditional correlation matrix of the stardardized disturbance at at time t.

The covariance matrix H_t is positive-definite by construction. Hence, H_t is the quadratic form based on R_t, the correlation matrix $\mathbf{R_t}$ should also be positive definite. Moreover, all the elements in the correlation matrix should not exceed 1 by definition. To insure that both of these requirements are met, R_t is decomposed as follows:

$$R_t = diag\{Q_t\}^{-1} Q_t diag\{Q_t\} \Leftrightarrow R_t = Q_t^{*-1} Q_t Q_t^{*-1} \quad (3)$$

$$Q_t^{*-1} = diag\{Q_t\}^{-1}$$

Q_t is a weighted average of a positive definite and a semi-definite matrix and can be expressed as

$$Q_t = (1 - a - b)\overline{Q} + a\, \mathcal{E}_{t-1}\mathcal{E}_{t-1}^T + b\, Q_{t-1} \quad (4),$$

where $\overline{Q} = E(\varepsilon_t \varepsilon_t')$ *is unconditional* covariance matrix of the standardized residual

The aim of the DCC-Garch model is to estimate the conditional correlation parameters a, b through a two step procedures. (Engle, 2001; Orskaug, 2009)

<u>The two-step estimation of the correlation parameters</u>

In practice, there is a two-step procedure to follow in order to estimate conditional correlation coefficients using DCC-GARCH. Firstly, the estimation of variance equations is performed for each time series. Secondly, the residuals from the first step are used to estimate volatility, or GARCH, model for each series. The residuals of the variance equations are then standardized by the transformation of their standard deviations from the first step and used in the second stage to estimate the conditional correlation estimates. Engle (2001) assumes the stardardized errors ϵ_t to be multivariate normally distributed. The normality assumption enables to estimate the parameters through the maximum Log likelihood method. Orskaug (2009) also considers the DCC-GARCH model where ϵ_t are multivariate student's t- and multivariate skew student's t- distributed. But, in this thesis, only the two-step estimation with the multivariate normally distributed errors will be considered.

Hence, assuming multivariate Gaussian distributed standardized errors, the log-likelihood function of the correlation estimator R_t can be written as follows (Orskaug, 2009) :

$$L = \frac{1}{2}\sum_{t=1}^{T}(n\log(2\pi) + \log|H_t| + a'_t H_t^{-1} a_t) \quad (1)$$

Then, substituting the conditional covariance-variance matrix by its expression $H_t \equiv D_t R_t D_t$ we obtain:

$$L = \frac{1}{2}\sum_{i-1}^{T}(n\log(2\pi) + \log|D_t R_t D_t| + a'_t D_t^{-1} R_t^{-1} D_t^{-1} a_t) \quad (2)$$

$$L = \frac{1}{2}\sum_{i-1}^{T}(n\log(2\pi) + 2\log|D_t| + \log|R_t| + a'_t D_t^{-1} R_t^{-1} D_t^{-1} a_t) \quad (3)$$

This formulation enables the analyst to estimate the parameters and perform their analysis easily even for large covariance matrices. Hence, Engle (2001) states that the log-likelihood in (3) can be equated as the sum of two quasi-likelihood functions where $QL_v(\theta_i)$ represents the volatility part and $QL_c(\theta_i,\phi)$ the correlation part:

$$L(\theta_i,\phi_{a,b}) = QL_v(\theta_i) + QL_c(\theta_i,\phi_{a,b})$$

Engle (2001) denotes θ_i as the parameters of the univariate GARCH models, $\theta_i = (\omega_i, \alpha_{1i}, \ldots \ldots, \alpha_{qi}, \beta_{1i}, \ldots \ldots \beta_{pi})$ and $\phi = (a,b)$ as the additional parameters in the correlation matrix R_t .

Stage one

θ_i are estimated in the first stage by replacing R in (3) with the identity matrix I_n. Hence, we obtain:

$$QL_v(\theta_i) = \frac{1}{2}\sum_{i-1}^{T}(n\log(2\pi) + 2\log|D_t| + \log|I_n| + a'_t D_t^{-1} I_n^{-1} D_t^{-1} a_t)$$

Since $\log|I_n| = 0$, we obtain:

$$QL_v(\theta_i) = \frac{1}{2}\sum_{i-1}^{T}(n\log(2\pi) + 2\log|D_t| + a'_t D_t^{-1} I_n^{-1} D_t^{-1} a_t)$$

Thus, it can be concluded that the quasi-likelihood function of the volatility part results in the sum of the individual GARCH likelihoods. Hence, the parameters of the univariate GARCH models can be individually estimated by maximizing the quasi-likelihood function of the volatility part. The estimations of the first stage imply that $\boldsymbol{\epsilon}_t = \boldsymbol{D}_t^{-1}$.

Stage two

Then in the next stage, the log-likelihood function as specified in (2) will help to determine the correlation parameters a and b given the estimations of the volatility parameters $\boldsymbol{\theta}_i$ from the first stage. The second stage quasi-likelihood function is expressed as follows, given that $\boldsymbol{\epsilon}_t = \boldsymbol{D}_t^{-1}$:

$$\boldsymbol{QL_c(\theta_i,\phi_{a,b}) = \frac{1}{2}\sum_{i-1}^{T}(n\log(2\pi) + 2\log|D_t| + \log|Rt| + \epsilon_t' R_t^{-1}\,\epsilon_t)}$$

When conditioned on the parameters from the first stage, it becomes a constant. Excluding constant terms from the equation, the final expression that has to be maximized to estimate the correlation parameters is :

$$\boldsymbol{QL_c(\theta_i,\phi_{a,b}) = \frac{1}{2}\sum_{i-1}^{T}(| + \log|Rt| + \epsilon_t' R_t^{-1}\,\epsilon_t)}$$

(Orskaug, 2009)

4.3 Estimation procedure

For the modeling of economic and financial time series, it is important to perform prior stationary tests on the variables. We must identify the trend of the series and validate what type it is, either deterministic (stationary) or stochastic (non stationary). Therefore, when working with time series variables, there are some empirical and statistical procedures that are involved before estimating the DCC-GARCH between stock and bond returns and the OLS between the dependent variable (DCC) and independent variables (FXSPOT, EXP, IMP, RES, SHIBOR3, INDPROD, INFL, M2, CC, BC, EPU).

According to Verbeek's (2004) definition of stationary: "Stationary requires that all the moments of the series, and not only the first and second (mean and variance), are unaffected by time".

In other words, a time series is stationary if its mean, variance and covariance remain constant over time. Thereby, a time series that is non-stationary is whether trending upwards or downwards. It will then be non-stationary if their mean values seem to evolve over time. (Thomas R.L., 1996)

Why do time series should be stationary?

One essential reason is to avoid spurious regressions such as false relation between two variables. Indeed, if one of the explanatory variables in a regression equation is non-stationary because it displays a distinct trend, it is very likely that the dependent variable in the equation will show a similar trend. One other reason to have stationary variables in our model is that according to economic theory, stationary variables will tend to return to their mean after a shock, independently of the magnitude of the shock. We will focus on an augmented Dickey-Fuller test to test the stationarity of the variables in our model. If this test confirms the non-stationarity of some variables, we perform the first difference or the log difference of these variables in order to have stationary variables.

After dealing with the stationary issue, we estimate the monthly correlations between the stock and government bond returns through the above-mentioned DCC-GARCH model as followed: SSE/BOND, SSE-A/BOND and SSE-B/BOND. Secondly, we verify if the correlation parameters meet the DCC-GARCH conditions.

Next, we investigate which monthly macro variables impact the monthly time-varying correlations between Chinese stock market and government bond market returns. In order to do so, we propose a lagged dependent variable model that we estimate through the Ordinary Least Squares (OLS) method. We analyze the goodness of fit of the regressions via the respective adjusted R measures.

Model 1: $Y_t = \alpha + \beta 2X_t + \varepsilon t$

Model 2: $Y_t = \alpha + \beta 1\ Y_{t-1} + \beta 2X_{t-1} + \varepsilon t$

The dependent variable Y_t represents the contemporaneous correlation at a monthly frequency between stocks and bonds returns of the SSE/BONDS, SSE-A/BONDS and SSE-B/BONDS.

The exogenous variable X_t designates the respective contemporaneous selected macro-finance factors. In the first model we did incorporate the contemporaneous factors in order to see the if the current value of Y_t depends on the current value of X . A Granger causality test will be performed to test whether the endogenous variable (Y_t) causes the exogenous variables (X_t) or not. We know that if X_t G-cause Y_t statistically significantly, thus it contains useful information that helps to predict future values of Y_t . However, if Y_t causes X_t it would mean that X_t and Y_t are both endogenous and VAR type of the model is needed.

The exogenous variable X_{t-1} designates the respective selected macro- finance factors, lagged by one period. In the second model, we purposefully did not include the contemporaneous variable X_t but included X_{t-1} as an independent variable in the first econometric model in order to reveal the causal effect of the respective factors on the stock and bond return correlations and not the other way around. In other words, X_{t-1} allows determining the persistence in time of the effect of the macro-finance variables and for the regression to be able to predict stock-bond return correlations. Second, we want to avoid inflated standard errors related to the multicollinearity between X_t and X_{t-1}. Moreover, we incorporated the lagged stock-bond return correlation (Y_{t-1}) on the right-hand side of all the models for the simple reason that we want to capture the dynamics of the stock-bond return correlations, control the time-persistence and autocorrelation of the stock and bond return correlation. In fact, the literature on the DCC-GARCH model of Engle (2002) has evidenced the dynamic correlation between stock and bond returns to be highly serially correlated (Ohmi & Okimoto, 2014). Hence, since we expect our model to be dynamic, not including the lagged dependent variable could potentially lead to an omitted variable bias. This would violate the Gauss-Markov theorem and result in biased and inconsistent OLS estimators. Including the lagged dependent variable (LDV) in the estimation allows us therefore to obtain robust estimates since the LDV should capture the first order auto-correlation (AR(1)) of the models' error terms.

Afterwards, we conduct Engle's ARCH test on the equations to see if incorporating the first lag of DCC is sufficient to entirely eliminate autocorrelation and heteroscedasticity. ARCH in itself does not invalidate inference, by using OLS, but can produce a loss in efficiency of the parameters. The ARCH test regresses the squared residuals of the regression on the lagged squared residuals and an intercept. The null hypothesis of the ARCH test states that no heteroscedasticity and autocorrelation effects on the regression's error term are present.

Once the models are estimated, we look at their in-sample goodness of fit through the respective adjusted R-squared. The R-squared measures the proportion of the variance of the dependent variable that is explained by the model, but increases by adding more explanatory variables in a regression, therefore we utilize the adjusted R-squared. Since, the adjusted R-squared will impose a penalty and compensate for the increasing number of explanatory variables. (Dougherty, 2007)

Final sample includes 105 observations of stock and bond monthly returns for each time series. The descriptive statistics for monthly stock and bond returns are presented in table 2. It includes mean, standard deviation, skewness, excess kurtosis, Bera-Jarque (B-J) test statistics and p-value for normality hypothesis testing in B-J test. The mean informs the average monthly return of asset, a greater value is highly preferable, and in contrast a negative mean is less appreciated by rational investors for diversification reason. China has negative mean in stock return denoting that stock return falls during the sample period. As consequence, investors are unable to benefit from diversification in the stock market and should be more attracted towards bond market. Similarly, standard deviation shows monthly volatility of the asset and desire to have low value to enjoy portfolio diversification.

Table 2, shows that the stock returns are on average lower than the bond returns. Returns distributions on both markets are not normal (as Jarque-Bara test indicates). The stock market is characterized by a negative skewness whereas the bond market by a positive skewness. Both markets exhibit excess kurtosis, which indicates that the probability distribution for both returns exhibits fatter tails than the normal distribution. `

Table 2: Reports the descriptive statistics of monthly stock and bond returns of China over October 2007 to January 2016

	Mean	Median	Max.	Min.	St.dev.	Kurtosis	Skewness	B-J
Stock returns (SSE)	-0,003	0,002	0,081	-0,123	0,039	4,105	-0,804	6,242 (.0441)
Stock returns (SSE-A)	-0,003	0,002	0,081	-0,123	0,039	4,106	-0,804	6,242 (.0441)
Stock returns (SSE-B)	0,000	0,004	0,117	-0,176	0,045	5,292	-0,806	6,242 (.0441)
Bond returns	0,002	0,001	0,051	-0,033	0,014	4,815	0,498	6,362 (.0415)

As per Mean-variance analysis (Markowitz 1987), the rational investor prefers to have higher expected returns at given level of risk. Table 2 illustrates that China bond market offers a higher expected monthly return than the SSE-B, SSE and SSE-A stock markets. The stock returns (SSE/SSE-A/SSE-B) have a higher volatility than the bond return which indirectly means that stock return demands more return in comparison to the bond one (Gulko, 2002). Within the stock market, the SSE-B returns are more volatile than the SSE-A returns.

Bera-Jarque (B-J) test is used to analyze the normality in time series of stock and bond returns. B-J test has been considered as one of the best and simple methods to test the normality of time series data. It examines skewness and kurtosis of individual data series with assumptions that normally distributed data have no skew, and kurtosis coefficient equal to 3 (Jarque and Bera, 1980). In table 2, the column headed skewness; kurtosis and B-J are used to analyze the normality of the data. The table shows that the skew value of China bond and stock markets have a different value than zero, showing presence of skewness in both asset series. Stock returns have negative skewness indicating an asymmetrical distribution with a long tail to the left (lower values). Bond returns have positive skewness indicating an asymmetrical distribution with a tail to the right (higher values). All asset returns have *leptokurtosis*, since the values are greater than 3 and it is one of the normal characteristic of time varying series. Theoretically, B-J coefficient needs to be equal or very close to zero, in order to display that the data are normally distributed (Jarque & Bera 1980); in the case of China's stock and bond return series have higher value than zero and strongly significant at the 1% level. Hence, on the basis of the B-J test, a conclusion is drawn that both asset return series are non-normally distributed.

Chapter 5. Empirical Results and Interpretations

5.1. DCC-GARCH estimation

The DCC-GARCH parameter estimates of the stock-bond return correlations were computed on Matlab with the code of kevin.sheppard (2001), which was retrieved from his website: https://www.kevinsheppard.com/UCSD_GARCH.

Here under are written the variance equations of both the stock returns and the bond returns

including one GARCH term ($h_{i,t-1}$) and one ARCH term ($a^2_{i,t-1}$).

The variance equations of the stock (SSE,,SSE-A and SSE-B) returns and the ten-year government bond returns, respectively, are the following:

$$H_{1,t} = \omega_1 + \alpha_1 \alpha^2_{1,t-1} + \beta_1 h_{1,t-1}$$

$$H_{2,t} = \omega_2 + \alpha_2 \alpha^2_{2,t-1} + \beta_2 h_{2,t-1}$$

Where ω_1 and ω_2 represent the respective intercepts, α_1 and α_2 the parameters of the ARCH terms, and $\beta_1$and β_2 the coefficients of the GARCH terms.

As explained in section 4.2, the correlation parameters a and b from the correlation matrix R are obtained by applying the maximum log-likelihood estimation method to the following equation:

$$R_t = Q_t^{*-1} Q_t Q_t^*; \text{ where } Q_t = (1 - a - b)\overline{Q} + a\, \mathcal{E}_{t-1}\mathcal{E}_{t-1}^T + b\, Q_{t-1} \text{ and } Q_t^{*-1} = diag\{Q_t\}^{-1}$$

The first hypothesis states that there is time varying conditional correlation between stock and bond return in China. We will use of Engle's (2001) DCC-GARCH model and see if the GARCH equation parameters meet their conditions to validate or reject the hypothesis.

Table 3 below presents the parameter estimates of the stock returns variance, of the 10-year government bond returns variance, and of the DCC-GARCH stock-bond return correlation.

Table3: Parameter estimates of the DCC-GARCH model

SSE	**variance parameters**		**10y Gov. Bond variance parameters**			**Correlation parameters**	
ω1	$\alpha1$	$\beta1$	ω2	$\alpha2$	$\beta2$	a	b
0.0003	0.1276	0.8257	0.0001	0.5857	0.1741	0.0365	0.5768
***	***	***	***	***	***	***	***
SSE-A	**variance parameters**		**10y Gov. Bond variance parameters**			**Correlation parameters**	
ω1	$\alpha1$	$\beta1$	ω2	$\alpha2$	$\beta2$	a	b
0.0004	0.1266	0.8267	0.0001	0.8978	0.0444	0.0342	0.5849
***	***	***	***	***	***	***	***
SSE-B	**variance parameters**		**10y Gov. Bond variance parameters**			**Correlation parameters**	
ω1	$\alpha1$	$\beta1$	ω2	$\alpha2$	$\beta2$	a	B

0.0011	0.1385	0.7452	0.0001	0.8978	0.0444	0.1897	0.2389
***	***	***	***	***	***	***	***

**** Significant at 1% level*

The conditions of the GARCH equation parameters are met since these outputs satisfy the conditions imposed by the DCC-GARCH model.

The parameters of the correlation equation, estimated for monthly returns, are highly significant rejecting the hypothesis that cross-asset correlation is constant over time. Moreover, as stated in section 4.2, $\alpha \geq 0$ and $\beta \geq 0$ $\alpha + \beta < 1$, indicating persistence in conditional correlation between monthly stock and bond returns.

Figure 1. Dynamics of the estimated correlation between stock(SSE) and bond returns

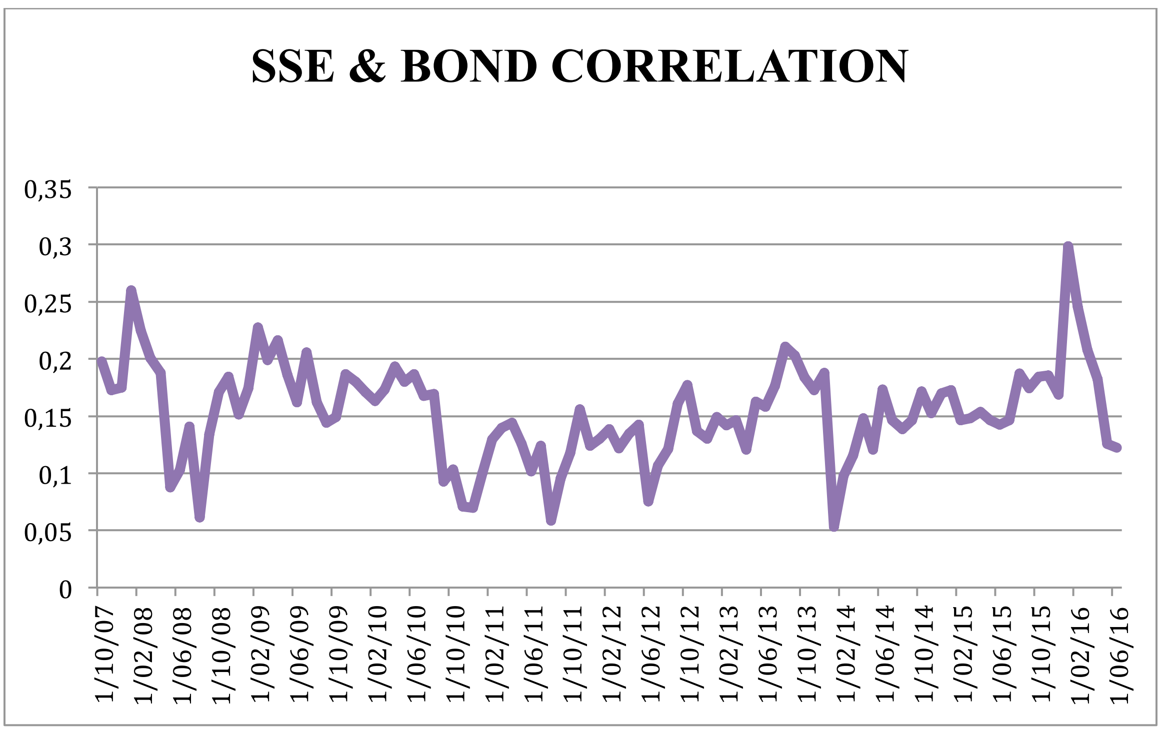


Figure 2. Dynamics of the estimated correlation between stock (SSE-A) and bond returns

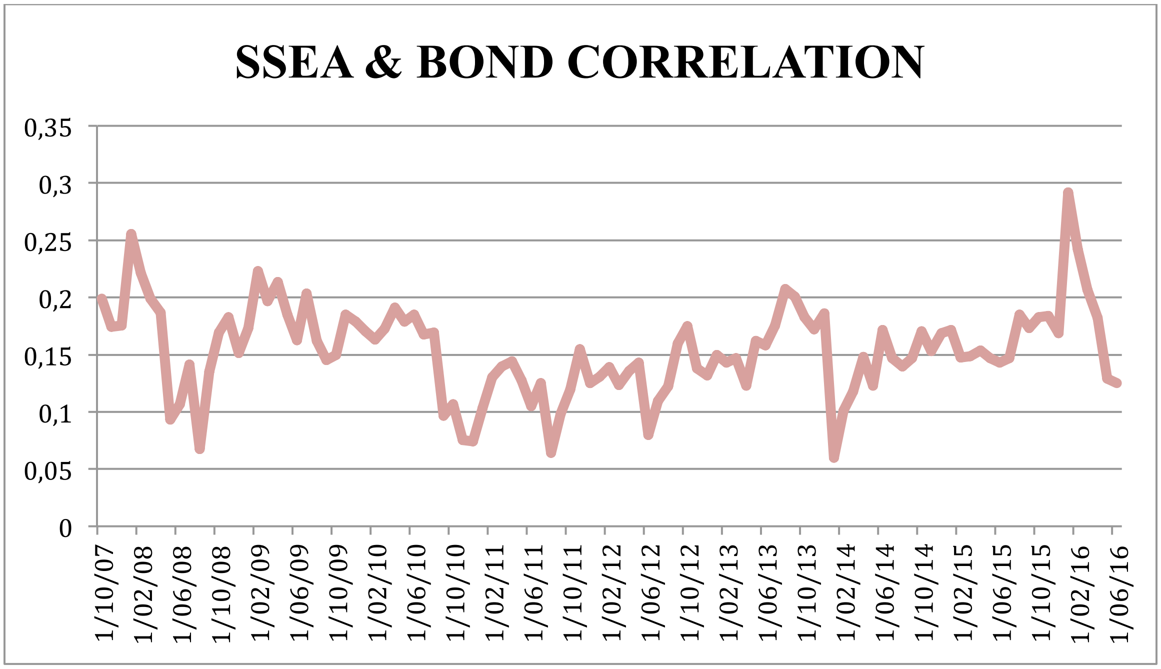
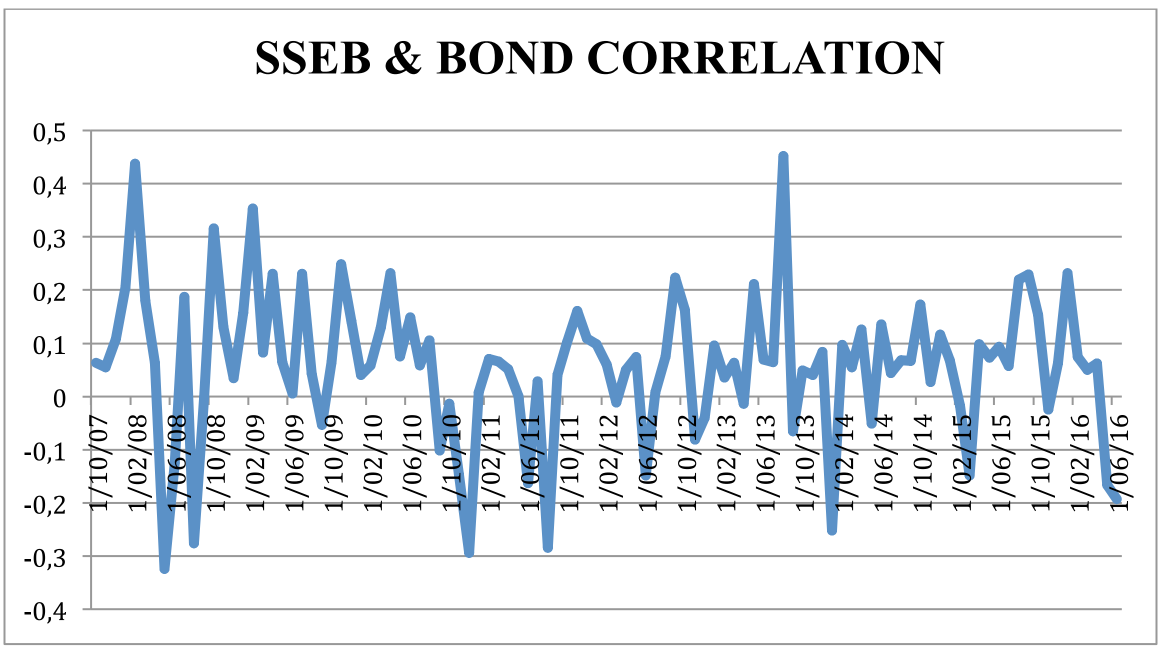


Figure 3. Dynamics of the estimated correlation between stock (SSE-B) and bond returns



The evolution of the estimated conditional correlations, highlighted by Figure 1, 2 and 3 reveal the time-varying nature of co-movements between stock and bond markets in China.

The SSE (DCC) and SSE-A/bond (DCC-A) return correlations display the exact same trends, since the latter represents more than 90% of the market value of the Shanghai composite index, thus we will consider them as a unique correlation (DCC). Whereas SSE-B/bond (DCC-B) return correlation exhibits totally dissimilar patterns thereby suggesting that different factors may determine the time-varying relation between the two main asset classes for figure 1 and 2 and figure 3. The DCC estimated utilizing monthly returns indicates that over the study period, stock-bond conditional correlations in the Chinese market estimated for monthly returns have been fluctuating primarily in the range of 0% to 30%. The correlation has always been positive whereas, DCC-B correlation varies more considerably over time, as we can clearly observe dramatic declines from positive to negative monthly correlations from 2008 to 2016. These declines illustrate the flight-to-safety periods following epochs of financial stress (Baele et al., 2010). These Graphs will be further discussed in next section 5.2.1.

5.2. Descriptive statistics

Category	Variable	Transfo.	Mean	Median	Max.	Min.	St.dev.	Obs.
	DCC (SSE)	**Level**	0,1535	0,1520	0,2988	0,0532	0,0421	105
Correlation	**DCC (SSE-A)**	**Level**	0,1539	0,1524	0,2916	0,0599	0,0399	105
	DCC (SSE-B)	**Level**	0,0590	0,0643	0,4517	-0,3239	0,1371	105
	FX	**Log**	0,065	0,064	0,075	0,061	0,003	105
	IMP	**Log**	0,019	0,018	0,573	-0,453	0,163	105
	EXP	**Log**	-2,071	-1,624	38,166	-103,112	12,038	105
Macro	**RES**	**Log**	0,008	0,007	0,044	-0,031	0,017	105
Economic	**SHIBOR**	**First diff.**	3,812	4,059	6,392	1,214	1,303	105
Variables	**IPI**	**Log**	0,007	0,000	1,351	-0,582	0,143	105
	INFL	**Log**	0,000	0,000	0,015	-0,026	0,006	105
	M2	**Log**	0,013	0,012	0,047	-0,013	0,011	105
	CC	**Log**	-0,001	-0,003	0,080	-0,052	0,022	105
	BC	**Log**	-0,003	0,000	0,104	-0,091	0,038	105
	EPU	**Log**	0,150	0,028	4,239	-0,829	0,660	105

The sub-sections below describe and interpret these descriptive statistics.

The second hypothesis states that stock-bond returns correlation is negative during financial crises and evidenced flight-to-safety phenomenon. This hypothesis will be tested by analyzing the average of the DCC-GARCH stock-bond correlation estimation over the sample period.

5.2.1 Stock-bond returns correlation

Over the sample period, the DCC displays an average value of 0,1535 and the DCC-B displays an average value of 0,059. The medians of DCC and DCC-B are -0.1520 and 0,0643 respectively. China demonstrates an overall low stock-bond correlation, which tends to be lower during financial crisis periods (cfr. 2008: Global financial crisis and 2015-16: Chinese stock market turbulence[2]) that in financial stability periods. This positive result corroborates Johnson et al. (2013) findings stipulating that the stock-bond return correlation is on average positive over long periods of time.

The lowest observed DCC and DCC-B amount is 0,0532 and -0,3239. The highest observed DCC and DCC-B amount is 0,2988 and 0,4517. The standard deviation of the DCC-B, which indicates the dispersion of the correlation around the mean, is much higher (0,1371) than the one of the DCC (0,0421). The correlation coefficient of DCC-B is frequently moving from positive to negative and vice-versa over the observation period, referring occurrence of regular flight-to-safety and contagion phenomenon. The DCC coefficient is less volatile and presents smaller deviations. Both results illustrate the great variation in stock and bond return correlations as indicated by the literature (Li, 2002; Ilmanen, 2003; Baele et al., 2010; Johnson et al., 2013).

The openness of a market is a plausible factor, which decides the answer to the issue of "contagion" effect versus "flight-to-safety" effect. Shuo (2011) assumed that closed markets are more likely to experience low or even negative stock-bond correlations, since it is difficult for external financial shocks to drive stock and bond market at the same time, and therefore make "contagion" effect weaker than "flight-to- safety" effect in closed economies.

[2] http://money.cnn.com/2015/07/09/investing/china-crash-in-two-minutes/

Additionally, for an investor, the lower the correlation between assets included in the portfolio, the better it is for diversification and, thus, the higher the reward-to-risk ratio would be.

5.2.2 Macro-economic variables

As we only focus on the sign of the impact the macro variables have on the dynamic conditional correlation between stock and bond returns, it is of no use to comment in detail the descriptive statistics of the macro-economic variables. The variables were transfomed into first difference in the natural log (FNDL) because it has some advantages. Indeed, using the FDNL reduces the Skewness and Kurtosis of the distribution of the variables. Thus, it strengthens the Normal distribution assumption of the regression. Moreover, it may improve the Goodness-of-fit (higher adjusted R-Squared, lower standard error). Finally, it may also improve the testing of the model resulting in residuals to be less heteroskedastic, and be closer to normally distributed.

The third hypothesis postulates that the correlation between stock and government bond returns is time-varying due to econometric and economic factors. Our empirical analysis will validate or reject the assumptions that heteroscedasticity and specific macro-economic factors contributes to the stock-bond return correlation dynamics .

5.3 Regression Model

In total, we performed six regressions. As assumed, the regressions, which have DCC and DCC-A as endogenous variables are really similar. Thus, our interpretations on the DCC will also serve as DCC-A interpretations. We will only comment on macro-economic factors that present high significances in the regressions[3]. We refer to appendix A.3 for the integral regression outputs of the models.

5.3.1 Linear Regression Model 1

The regression Model 1 outputs, using DCC as endogenous variable, suggest that only RES, SHIBOR and BC significant drivers of the monthly stock and bond return correlations.

The p-value of RES (0,047795) is lower than 0.05. This probability suggests that the negative coefficient of the International reserves in USD (-0.50621) is highly significant at 5 % significance level. Hence, a negative relationship exists between the International reserves in USD and the stock-bond return DCC. This result confirms Aslanidis and Christiansen (2014) research. The coefficient of SHIBOR is significant at 1% significance level. It appears that one basis point increase in the monthly SHIBOR could cause a 0,01% decrease in the monthly correlations for one basis point increase in the Shanghai interbank offered rate (3-month), ceteris paribus. The p-value (0,082801) of BC is significant at 10% significance level. This implies a positive strong relationship between the business cycle and the monthly DCC. These results for SHIBOR and BC are in line with Baxter and Crucini (1995).

The model, using DCC-B as endogenous variable, shows SHIBOR and IPI are significant drivers of the monthly stock and bond return correlations. SHIBOR negative coefficient (-0,020557) suggests a negative impact on the conditional correlations with a 10% significance level. The p-value of IPI (0,031399) indicates a positive relationship between the industrial production index and the contemporaneous stock-bond correlation.

[3] A variable is significant at the 1%, 5% or 10% significance level if the p-value of the estimated parameter is lower than 0.01, 0.05 or 0.1. Indeed, in these cases, the null hypothesis, stating that the estimated coefficient is equal to zero, is rejected. Appendix A.3. reports the p-values of the parameters. (Dougherty, 2007)

A Granger causality test is performed on the significant contemporaneous variables in order to see whether the endogenous variable (DCC) causes the macro variables or the macro variables cause the DCC.

The results of the test demonstrate that we cannot reject the null hypothesis stipulating that the conditional correlation does not Granger Cause the contemporaneous macro variables.

5.3.2 Linear Regression Model 2

Since these independent variables are lagged, the results imply that their causal effects on the monthly stock-bond return correlation are time-persistent. The result of the outputs indicates that the past values of the significant macro-finance factors contain valuable information to predict the current stock-bond return correlations.

In the model, using DCC as endogenous variable, EXP and RES are highly significant. The p-value of EXP (0,013801) indicates that the lagged EXP is highly significant at the 5% significance level. This implies a positive relationship between the exportations and DCC. The exportation of the previous period is thus a significant predictor of the current stock-bond return correlation.

Finally, at monthly frequency, RES also appears to be a negative driver of the stock-bond return correlation. The p-value of the RES estimate (0,050237) indicates this relationship to be significant at 10% critical level. As such, a 0.01 increase in the lagged international reserve, would predict a 0,42% decrease of the monthly correlation, c*eteris paribus*.

The lagged exportations are also significant in the DCC-B model. The p-value of EXP (0,0059681) indicates that the lagged EXP is highly significant at the 1% significance level. This also implies a strong positive relationship between the exportations and DCC.

5.3.3 Remarks on regression

Thus far, we have only focused on the significance of the macro-finance determinants within the respective models. However, three additional observations need to be highlighted with regards to serial correlation, the model fit as measured by the adjusted R and the DCC-B.

First, as mentioned in the section 4.2. Estimation procedure, we include the lagged dependent variable in the three models in order to capture serial correlations. The regression results tables in Appendix A.3. show that the coefficient of the lagged correlation, $\beta 1$, remains highly significant throughout the regressions within the three models. Furthermore, in order to test whether the inclusion of the first period lagged correlation is able to eliminate serial correlation, we conduct Engle's ARCH test on all our equations. ARCH in itself does not invalidate inference using OLS but can produce a loss in efficiency of the parameters. We refer to appendix A.3. for a description of the ARCH test and the detailed outputs of this test. We cannot reject the null hypothesis of no ARCH across all the regressions. This finding suggests that incorporating the first lag of DCC is sufficient to entirely eliminate autocorrelation and heteroscedasticity. Hence, the OLS estimators are efficient.

Second, as in Li (2002), it is interesting to observe that the adjusted R-squared measures reveal important variations across the different models. Indeed, the highest adjusted R-squared equals 0,418 (DCC-A model 1) and the equals lowest 0,0612. (DCC-B model2). These findings suggest 41,8% of the variance of the monthly SSEA/BOND return correlations and 8,57% of the variance of the monthly SSEB/BOND return correlations are explained by the proposed models. In fact, the observations indicate that the conditional variance of the stock-bond correlation is better explained by adding one period lag. We can link this to the research of Asgharian et al. (2014) who consider it crucial to include the realized (lagged) correlations as an independent variable in order to increase the performance of their model.

Thirdly, we can observe that the DCC-A and the DCC-B are not affected by the same factors. Indeed, two macro-factors impacted the DCC-B in model 1 and only one impacted in model 2. Moreover, the adjusted R-squared were really low which indicates that the conditional variance of the stock-bond correlation is barely explained by the regressors. It might be of interest to examine in further research what factors may cause a stronger time-variation in the DCC-B.

Chapter 6 : Conclusion

This thesis has for purpose to examine the dynamic relationship between Chinese stock and bond returns. Our study analyses data from October 2007 and ends in June 2016. This period is essentially marked by the 2008 global financial crisis and 2015-2016 stock market turbulence. This was of particular interest of this master's thesis, since one of the objectives was to understand flight-to-safety; a phenomenon occurring during epochs of financial stress producing prolonged periods of negative correlations. Our research was motivated by the desire to examine the correlation dynamics between the bonds and the stocks for diversification purposes in the context of dynamic asset allocation. For the empirical analysis, we proceeded by estimating the correlations using the DCC-GARCH model. To determine the key drivers of the monthly correlations between stocks and government bonds, we performed 6 linear regressions.

Finally, we will conclude by *(i)* providing a summary of the empirical results, *(ii)* by discussing the impact of these findings on dynamic asset allocation, and, finally, *(iii)* by presenting this master's thesis limitations.

6.1. Summary of empirical results

Through empirical analysis, we attempted to provide an answer to the empirical questions evoked in the introduction.

- What sorts of conditional correlation exist between the stock and bond returns in China?
- What are the main drivers of the dynamic correlation?
- How does the stock-bond returns correlation evolve during financial crises?
- How can investors benefit from portfolio diversification?

First of all, the highly significant DCC-GARCH parameter estimates provide evidence of the time-varying nature of the correlation and evidence for heteroscedasticity being an important driver of the stock-bond return correlation. This is consistent with Baele et al. (2010) and Connolly et al. (2005) amongst many others.

As in Johnson et al. (2013), and Baele et al. (2010) the estimated dynamic conditional correlations have proven to be highly variant. The SSE-A stock-bond returns correlation follows the same trends than the SSE stock-bond returns correlation. Indeed, over the sample period, the monthly stock and government bond correlations range from 0,0532 to 0,2988 for the SSE and from 0,0599 to 0,2916 for the SSE-A. Since both are really close, we consider them as a unique conditional correlation (DCC) to simplify the interpretations. The DCC stays always positive even during financial crises. Whereas SSE-B/bond (DCC-B) returns correlation is more volatile, ranging from -0,3239 to 0,4517 over the sample period. It exhibits more marked patterns with more important variations, sometimes negative during crises, thereby suggesting that different factors may determine the time-varying relation between the two main asset classes. Shuo (2011) assumed that close markets are more likely to experience low or even negative stock-bond correlations, since it is difficult for external financial shocks to drive stock and bond market at the same time, and therefore make "contagion" effect weaker than "flight-to-quality" effect in close economies.

This thesis proposed six different regressions to examine the relationship between the dynamic conditional correlation and the eleven macro-economic factors.

The regression Model 1, using DCC or DCC-A as endogenous variable, has shown that the contemporaneous RES, SHIBOR and BC significant drivers of the monthly stock and bond return correlations. The research, exhibits RES and SHIBOR have a negative impact on the stock-bond return correlation, whereas the relationship between BC and the DCC is positive, confirming Aslanidis et al.(2014) and Baxter et al. (1995) findings.

In the model, using DCC-B as endogenous variable, SHIBOR and IPI have proved to be significant drivers indicating SHIBOR as a negative and IPI as a positive driver of the contemporaneous stock-bond correlation.

The regression Model 2 is a model containing lagged independent variables. The results obtained indicate that the past values of the significant macro-finance factors contain valuable information to predict the current stock-bond return correlation.

The model, using DCC or DCC-A as endogenous variable, demonstrates that EXP_{t-1} and RES_{t-1} are highly significant. Unlikely, the model with DCC-B as endogenous variable only shows EXP_{t-1} as a significant driver of the contemporaneous correlation. EXP_{t-1} is a positive driver, whereas RES_{t-1} is a negative driver of the current stock-bond return correlation.

This research demonstrates that the DCC-A and the DCC-B are not affected by the same factors. Indeed, two macro-factors impacted the DCC-B in model 1 and only one impacted in model 2. Hence, explaining that the DCC-B is more volatile than DCC-A. Moreover, the adjusted R-squared were significantly low, which indicates that the conditional variance of the stock-bond correlation is barely explained by the regressors. It might be of interest to examine in further research what factors may cause a stronger time-variation in the DCC-B.

6.2. Implications on dynamic asset allocation

From our empirical results it appears that an investor who would have held a portfolio composed of solely stocks and government over our sample period, would have been able to reduce his risk with a minimal impact on his return. Indeed, the portfolio variance formula of Markowitz' Portfolio Theory indicates that a low or a negative correlation between assets allows for a reduced portfolio variance, hence, risk.

As stated by Philips et al. (2012), we also find it crucial for portfolio investors to understand and anticipate the responses of the stock and government bond return correlation to various market dynamics. We would advise investors to closely monitor the international reserves, Shanghai interbank offered rate 3-month and the business cycle index and the exportations if they want to invest in the A-shares. However, we would recommend B-shares investors to watch Shanghai interbank offered rate 3-month, the industrial production index and the exportations. Consequently, a portfolio investor should keep a close eye on these variables, at their respective frequencies, and actively adjust his portfolio in response to market shocks. Furthermore, the strong volatility relationship between both stock and government bond markets is very interesting from a diversification point of view. Indeed, in times of financial stress, the stock and government bond correlation tends to be negative. This appears to be a great opportunity for a portfolio investor wishing to benefit from diversification.

6.3 Limitations and direction for further researches

A first limitation of our empirical research is the range of the sample period. The empirical investigation of this thesis starts in October 2007 and ends in June 2016. Future researchers may wish to work with data for a longer time-period with proper control for time-varying measures. Hence, the sign issue of the correlation between stock and bond returns might be different for longer period as Baele et al. (2010) had already noted.

A second limitation is the scarcity on reliable data to study the factors influencing the stock-bond correlation, consequently limiting the scope of our analysis. In the near future possibly new data would be available and thus, future researches considering previous significant macroeconomic factors to the new ones would be fruitful to study.

Lastly, this research is limited to the investigation of the correlation between stock and government bond returns solely. Therefore, this research was based on the assumption that stocks and government bonds were the main assets composing a portfolio. However, in practice, a portfolio might include other assets besides stocks and government bonds. For instance, a portfolio investor could be composed by derivatives, other debt instruments such as corporate bonds, or alternative investments such as commodities and private equity. Hence, from an asset allocation point of view, it would be highly interesting to implement this research on a larger scale.

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Appendices

A.1.: Stationary testing using the Augmented Dickey-Fuller (ADF) test

The *Augmented Dickey-Fuller test for a unit root* assesses the null hypothesis of a unit root using the model

$$y_t = c + \delta t + \phi y_{t-1} + \beta_1 \Delta y_{t-1} + \ldots + \beta_p \Delta y_{t-p} + \varepsilon_t,$$

where

- Δ is the differencing operator, such that $\Delta y_t = y_t - y_{t-1}$.
- The number of lagged difference terms, p, is user specified.
- ε_t is a mean zero innovation process.

The null hypothesis of a unit root is H_0:ϕ=1. Under the alternative hypothesis, ϕ<1.

Variants of the model allow for different growth characteristics. The model with $\delta = 0$ has no trend component, and the model with $c = 0$ and $\delta = 0$ has no drift or trend.

A test that fails to reject the null hypothesis, fails to reject the possibility of a unit root.

Matlab code

```
[h7,pValue7] = adftest(D(:,7))
[h8,pValue8] = adftest(D(:,8))
[h9,pValue9] = adftest(D(:,9))
[h10,pValue10] = adftest(D(:,10))
[h11,pValue11] = adftest(D(:,11))
[h12,pValue12] = adftest(D(:,12))
[h16,pValue16]  = adftest(D(:,16))
[h17,pValue17] = adftest(D(:,17))
[h18,pValue18] = adftest(D(:,18))
[h19,pValue19] = adftest(D(:,19))
[h20,pValue20] = adftest(D(:,20))
[h21,pValue21] = adftest(D(:,21))
[h22,pValue22] = adftest(D(:,22))
```

The Matlab outputs below present the results of the ADF unit root test on the level or transformed variables as defined in Table 1 supra. *Note that if the result h = 0, it indicates that this test fails to reject the null hypothesis of a unit root against the autoregressive alternative.*

Stock

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h7 = 1

pValue7 = 1.0000e-03

Bond

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h8 = 1

pValue8 = 1.0000e-03

FX

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h9 = 1

pValue9 = 1.0000e-03

EXP

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h10 = 1

pValue10 = 1.0000e-03

IMP

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h11 = 1

pValue11 = 1.0000e-03

RES

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h12 = 1

pValue12 = 1.0000e-03

SHIBOR

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h16 = 1

pValue16 = 1.0000e-03

IPI

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h17 = 1

pValue17 = 1.0000e-03

INFL

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h18 = 1

pValue18 = 1.0000e-03

M2

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h19 = 1

pValue19 = 1.0000e-03

CC

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h20 = 1

pValue20 = 1.0000e-03

BC

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h21 = 1

pValue21 = 1.0000e-03

EPU

Warning: Test statistic #1 below tabulated critical values:

minimum p-value = 0.001 reported.

> In adftest>getPValue at 1135

In adftest>getStat at 1096

In adftest at 421

h22 = 1

pValue22 = 1.0000e-03

A.2.: Estimation of the DCC-GARCH correlations in MatLab

```
PURPOSE:
%    Test for presence of dynamic correlation
%
% USAGE:
%    [pval, stat]=dcc_mvgarch_test(data,archP,garchQ,nlags);
%
% INPUTS:
%    data  - T by k matrix of residuals to be tested or dynamic corrrelation
%    archP - The length of the news terms in each univariate garch(either a scalar or a k by 1 vector)
%    garchQ - The length of the smoothing terms in each univariate garch(either a scalar or a k by 1 vector)
%    nlags - THe number of lags to use in the test
%
% OUTPUTS:
%    pval - The probability the correlation is constant
%    stat - The Chi^2 stat, with nlags+1 D.F>
%
% COMMENTS:
% Author: Kevin Sheppard
% kevin.sheppard@economics.ox.ac.uk
% Revision: 2    Date: 12/31/2001
[t,k]=size(data)
if isempty(archP)
   archP=ones(1,k);
elseif length(archP)==1
   archP=ones(1,k)*archP;
end
if isempty(garchQ)
   garchQ=ones(1,k);
elseif length(garchQ)==1
```

```
    garchQ=ones(1,k)*garchQ;
end
[holder,holder2,holder3,holder4,holder5,stdresid]=cc_mvgarch(data,archP,garchQ);
outerprods=[];
for i=1:k
    for j=i+1:k;
        outerprods=[outerprods stdresid(:,i).*stdresid(:,j)];
    end
end
j=size(outerprods,2);
regressors=[];
regressand=[];
for i=1:j
    [Y,X]=newlagmatrix(outerprods(:,i),nlags,1);
regressors=[regressors; X];
    regressand=[regressand; Y];
end
beta=regressors\regressand;
XpX=(regressors'*regressors);
e=regressand-regressors*beta;
sig=e'*e/(length(regressors-nlags-1));
stat=beta'*XpX*beta/sqrt(sig);
pval=1-chi2cdf(stat,nlags+1);
% DCC model
[parameters, ll ,Ht, VCV, scores, diagnostics,corr_vechR,vechN]=dcc(Y,[],1,0,1,[],[],[],2,[],[],[],[]);

% COEFFICIENTS DES PARAMETRES
%      parameters    = A vector of parameters estimated form the model of the form
%                      [GarchParams(1) GarchParams(2) ... GarchParams(k) DCCParams]
%                      where the garch parameters from each estimation are of the form
```

```
%                          [omega(i) alpha(i1) alpha(i2) ... alpha(ip(i)) beta(i1)


% ISOLER LES COVARIANCES
for j=1:size(Ht,3)
    COV(j,1)=Ht(1,2,j);
    VARA(j,1)=Ht(1,1,j);
    VARB(j,1)=Ht(2,2,j);
end
CORR=COV./(sqrt(VARA).*sqrt(VARB));
plot(CORR)


% XLSWRITE
%filename = 'data in on excel sheet.xlsx';
%sheet = 'Results';
%xlswrite(filename,CORR,sheet)
```

A.3.: Regression results

Matlab code

```
% LAGGED OLS REGRESSION
X= [CORR D(2:end,9:12) D(2:end,14) D(2:end,17:end)];
X=X(1:end-1,:);
Z=CORR(2:end,:);


% OLS CONTEMPORENOUS
X= [CORR(:,1:end-1) D(3:end,9:12) D(3:end,14) D(3:end,17:end)];
Z=CORR(2:end,:);
mdl2 = fitlm(X,Z)
```

Linear regression model 1:

DCC~ 1 + x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8 + x9 + x10 + x11,

where, x1 = FX , x2 = IMP, x3= EXP , x4 = RES , x5 = SHIBOR , x6= IPI , x7 = INFL , x8= M2, x9= CC, x10 = BC, x11 = EPU .

	Estimate	SE	tStat	pValue
(Inter)	0.064536	0.1084	0.59535	0.55309
x1	2.0894	1.5737	1.3277	0.1876
x2	-0.012723	0.027066	-0.47007	0.63943
x3	0.00025015	0.00033943	0.73698	0.46303
x4	-0.50621	0.25231	-2.0063	0.047795(**)
x5	-0.010389	0.0035578	-2.92	0.0044119(***)
x6	0.017933	0.028925	0.62	0.53681
x7	-0.17103	0.75428	-0.22675	0.82113
x8	-0.14862	0.36998	-0.4017	0.68884
x9	0.2186	0.17902	1.2211	0.22522
x10	0.20502	0.11689	1.754	0.082801(*)
x11	0.0033806	0.0061862	0.54647	0.58608
Number of observations: 103, Error degrees of freedom: 91 Adjusted R-Squared 0.159 *(***) Significant at 1% level, (**) Significant at 5% level,* (*): *Significant at 10% level*				

DCC A~ 1 + x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8 + x9 + x10 + x11,

where, x1 = FX , x2 = IMP, x3= EXP , x4 = RES , x5 = SHIBOR , x6= IPI , x7 = INFL , x8= M2, x9= CC, x10 = BC, x11 = EPU .

	Estimate	**SE**	**tStat**	**pValue**
(Inter)	**0.064265**	**0.1025**	**0.62696**	**0.53225**
x1	**2.0592**	**1.488**	**1.3838**	**0.16979**
x2	**-0.011858**	**0.025593**	**-0.46333**	**0.64424**
x3	**0.00024051**	**0.00032096**	**0.74936**	**0.45557**
x4	**-0.47773**	**0.23858**	**-2.0024**	**0.04822(**)**
x5	**-0.0098137**	**0.0033642**	**-2.9171**	**0.0044498(***)**
x6	**0.016901**	**0.027351**	**0.61791**	**0.53818**
x7	**-0.15274**	**0.71324**	**-0.21415**	**0.83091**
x8	**-0.14319**	**0.34985**	**-0.40928**	**0.6833**
x9	**0.20497**	**0.16928**	**1.2108**	**0.22911**
x10	**0.19448**	**0.11053**	**1.7595**	**0.081853 (*)**
x11	**0.0031413**	**0.0058496**	**0.53701**	**0.59257**
Number of observations: 103, Error degrees of freedom: 91 **Adjusted R-Squared 0.162** ***(***) Significant at 1% level, (**) Significant at 5% level,* (*): *Significant at 10% level***				

DCC B~ 1 + x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8 + x9 + x10 + x11,

where, x1 = FX , x2 = IMP, x3= EXP , x4 = RES , x5 = SHIBOR , x6= IPI , x7 = INFL , x8= M2, x9= CC, x10 = BC, x11 = EPU .

	Estimate	**SE**	**tStat**	**pValue**
(Inter)	**-0.031964**	**0.36787**	**0.086889**	**0.93095**
x1	**2.9376**	**5.3404**	**0.55006**	**0.58362**
x2	**-0.016874**	**0.091852**	**-0.18371**	**0.85465**
x3	**-0.00056038**	**0.0011519**	**-0.48649**	**0.62779**
x4	**-1.3207**	**0.85624**	**-1.5425**	**0.12642**
x5	**-0.020557**	**0.012074**	**-1.7027**	**0.092046(*)**
x6	**0.21456**	**0.09816**	**2.1858**	**0.031399(**)**
x7	**-2.4854**	**2.5597**	**-0.97095**	**0.33415**
x8	**-0.79842**	**1.2556**	**-0.6359**	**0.52644**
x9	**0.80799**	**0.60753**	**1.33**	**0.18685**
x10	**0.45132**	**0.39668**	**1.1377**	**0.25822**
x11	**0.0039988**	**0.020994**	**0.19048**	**0.84936**

Number of observations: 103, Error degrees of freedom: 91

Adjusted R-Squared 0.0612

(***) Significant at 1% level, (**) Significant at 5% level,* (*): *Significant at 10% level

Linear regression model 2:

DCC ~ 1 + x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8 + x9 + x10 + x11 + x12,

where x1 = DCC_{t-1}, x2 = FX_{t-1}, x3 = IMP_{t-1}, x4= EXP_{t-1}, x5 = RES_{t-1}, x6 = $SHIBOR_{t-1}$, x7= IPI_{t-1}, x8 = $INFL_{t-1}$, x9 = $M2_{t-1}$, x10= CC_{t-1}, x11 = BC_{t-1}, x12 = EPU_{t-1}.

	Estimate	**SE**	**tStat**	**pValue**
(Inter)	**0.01952**	**0.084835**	**0.2301**	**0.81853**
x1	**0.52638**	**0.087522**	**6.0143**	**3.7129e-08 (***)**
x2	**1.1252**	**1.246**	**0.90305**	**0.36888**
x3	**0.009042**	**0.022684**	**0.3986**	**0.69112**
x4	**0.00071547**	**0.00028492**	**2.5111**	**0.013801 (**)**
x5	**-0.42602**	**0.2147**	**-1.9843**	**0.050237(*)**
x6	**-0.0045128**	**0.0030512**	**-1.479**	**0.14259**
x7	**0.015796**	**0.024191**	**0.65297**	**0.51542**
x8	**0.35493**	**0.63064**	**0.56282**	**0.57494**
x9	**0.15735**	**0.30826**	**0.51044**	**0.61098**
x10	**0.0078391**	**0.15103**	**0.051906**	**0.95872**
x11	**-0.060848**	**0.099484**	**-0.61164**	**0.5423**
x12	**-0.0050778**	**0.0051822**	**-0.97986**	**0.32975**
Number of observations: 105, Error degrees of freedom: 91				
Adjusted R-Squared 0.408				
(***) Significant at 1% level, (**) Significant at 5% level,* (*)*: Significant at 10% level				

DCCA ~ 1 + x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8 + x9 + x10 + x11 + x12,

where x1 = DCC_{t-1}, x2 = FX_{t-1}, x3 = IMP_{t-1}, x4= EXP_{t-1}, x5 = RES_{t-1}, x6 = $SHIBOR_{t-1}$, x7= IPI_{t-1}, x8 = $INFL_{t-1}$, x9 = $M2_{t-1}$, x10= CC_{t-1}, x11 = BC_{t-1}, x12 = EPU_{t-1}.

	Estimate	**SE**	**tStat**	**pValue**
(Inter)	**0.020767**	**0.079705**	**0.26055**	**0.79503**
x1	**0.53355**	**0.086915**	**6.1387**	**2.1392e-08(***)**
x2	**1.0725**	**1.1724**	**0.91477**	**0.36273**
x3	**0.0086799**	**0.021311**	**0.4073**	**0.68475**
x4	**0.00066993**	**0.00026771**	**2.5025**	**0.014119(**)**
x5	**-0.40154**	**0.20172**	**-1.9906**	**0.049525 (*)**
x6	**-0.0042291**	**0.0028652**	**-1.476**	**0.1434**
x7	**0.014911**	**0.022726**	**0.6561**	**0.51341**
x8	**0.3301**	**0.59246**	**0.55716**	**0.57879**
x9	**0.14536**	**0.28963**	**0.50187**	**0.61697**
x10	**0.007477**	**0.14187**	**0.052705**	**0.95808**
x11	**-0.056775**	**0.093475**	**-0.60738**	**0.54511**
x12	**-0.0048106**	**0.0048683**	**-0.98816**	**0.3257**
Number of observations: 105, Error degrees of freedom: 91				
Adjusted R-Squared 0.418				
(***) Significant at 1% level, (**) Significant at 5% level, (*): Significant at 10% level				

DCCB ~ 1 + x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8 + x9 + x10 + x11 + x12,

where x1 = DCC_{t-1}, x2 = FX_{t-1}, x3 = IMP_{t-1}, x4= EXP_{t-1}, x5 = RES_{t-1}, x6 = $SHIBOR_{t-1}$, x7= IPI_{t-1}, x8 = $INFL_{t-1}$, x9 = $M2_{t-1}$, x10= CC_{t-1}, x11 = BC_{t-1}, x12 = EPU_{t-1}.

	Estimate	**SE**	**tStat**	**pValue**
(Inter)	**-0.016153**	**0.34323**	**-0.047062**	**0.96257**
x1	**0.22728**	**0.10469**	**2.1708**	**0.032545 (**)**
x2	**1.5517**	**4.9758**	**0.31184**	**0.75588**
x3	**0.0025739**	**0.091748**	**0.028054**	**0.97768**
x4	**0.003243**	**0.0011518**	**2.8156**	**0.0059681(***)**
x5	**-0.64733**	**0.86003**	**-0.75268**	**0.45358**
x6	**-0.013625**	**0.01204**	**-1.1317**	**0.26073**
x7	**-0.021285**	**0.10033**	**-0.21216**	**0.83246**
x8	**2.4673**	**2.5662**	**0.96148**	**0.33886**
x9	**1.8041**	**1.2493**	**1.4441**	**0.15215**
x10	**-0.18796**	**0.61254**	**-0.30686**	**0.75965**
x11	**-0.61962**	**0.39885**	**-1.5535**	**0.12377**
x12	**-0.003015**	**0.020955**	**-0.14388**	**0.88591**

Number of observations: 105, Error degrees of freedom: 91

Adjusted R-Squared 0.0857

(***) Significant at 1% level, (**) Significant at 5% level, **(*):** ***Significant at 10% level***

A.4.: Granger causality test

The null hypothesis is that the y does not Granger Cause x. A user specifies the two series, x and y, along with the significance level and the maximum number of lags to be considered. The function chooses the optimal lag length for x and y based on the Bayesian Information Criterion. The function produces the F-statistic for the Granger Causality Test along with the corresponding critical value. We reject the null hypothesis that y does not Granger Cause x if the F-statistic is greater than the critical value. (Chandler, 2009)

GRANGER TEST

```
[F,c_v] = granger_cause(x,y,alpha,max_lag)
% Granger Causality test
% Does Y Granger Cause X?
%
% User-Specified Inputs:
%   x -- A column vector of data
%   y -- A column vector of data
%   alpha -- the significance level specified by the user(on a choisit 5%)
%   max_lag -- the maximum number of lags to be considered
% User-requested Output:
%   F -- The value of the F-statistic
%   c_v -- The critical value from the F-distribution
```

<u>Matlab code</u>

```
%GRANGER CAUSALITY TEST
H= [CORR(1:end,:) D(2:end,9:12) D(2:end,14) D(2:end,17:end)];

% function prise sur
[F1,c1] = granger_cause(D(2:end,9),CORR,0.05,1)
[F2,c2] = granger_cause(D(2:end,10),CORR,0.05,1)
[F3,c3] = granger_cause(D(2:end,11),CORR,0.05,1)
[F4,c4] = granger_cause(D(2:end,12),CORR,0.05,1)
[F5,c5] = granger_cause(D(2:end,14),CORR,0.05,1)
[F6,c6] = granger_cause(D(2:end,17),CORR,0.05,1)
[F7,c7] = granger_cause(D(2:end,18),CORR,0.05,1)
[F8,c8] = granger_cause(D(2:end,19),CORR,0.05,1)
[F9,c9] = granger_cause(D(2:end,20),CORR,0.05,1)
[F10,c10] = granger_cause(D(2:end,21),CORR,0.05,1)
[F11,c11] = granger_cause(D(2:end,2),CORR,0.05,1)
```

DCC

RES
F4 = 2.3478
c4 =3.9343

SHIBOR
F5 = 3.3584
c5 = 3.9343

BC
F10 = 2,8974
c10 = 3.9343

DCC-B
SHIBOR
F5 =3.7472
c5 = 3.9343

IPI
F6 = 2.9165
c6 = 3.9343

A.5.: ARCH test

In order to test whether the inclusion of the first period lagged correlation is able to eliminate serial correlation, we conduct Engle's ARCH test on all our equations. ARCH in itself does not invalidate inference using OLS but can produce a loss in efficiency of the parameters. The ARCH test regresses the squared residuals of the regression on the lagged squared residuals and an intercept. The null hypothesis of the ARCH test states that no heteroscedasticity and autocorrelation effects on the regression's error term are present. We evaluate the presence of ARCH through Engle's (1982) Lagrange Multiplier test statistic. T

- h = 1 indicates rejection of the no ARCH effects null hypothesis in favor of the alternative.
- h = 0 indicates failure to reject the no ARCH effects null hypothesis.

Matlab code

```
% ARCH TEST
clear X
X= [ones(size(D,1)-1,1) CORR D(2:end,9:12) D(2:end,14) D(2:end,17:end)];
X=X(1:end-1,:);
beta=inv(X'*X)*X'*Z;
res=Z-X*beta;
[h,pValue,stat,cValue] = archtest(res)
```

DCC

h = 0

pValue = 0.4092

stat = 0.6812

cValue = 3.8415

DCC-A

h =0

pValue = 0.4141

stat = 0.6670

cValue = 3.8415

DCC-B

h =0

pValue = 0.5754

stat = 0.3137

cValue = 3.8415