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LUND UNIVERSITY
School of Economics and Management

An Analysis of Financial Stress in the Chinese Economy: A TVAR Approach

Abstract

In this paper, we look to develop understanding of the nature and potential impact of financial stress and fiscal shocks in the Chinese economy, examining how such stress spreads through the economy and how monetary policy can exaggerate or mitigate the resultant effects. In order to do so, we construct a TVAR model on Chinese quarterly data. To achieve that we develop a financial stress index comprising of four distinct sub-indices, each covering a key sector of the domestic economy and designed with the specificities of the Chinese economic landscape in mind. The model shows that China experiences apparently cyclical periods of financial stress, resulting from both exogenous and endogenous sources, and the shock impulse analysis provides a dynamic illustration of how our chosen dependent variables of GDP growth, Inflation and CHIBOR react to shifts in the economic environment. We demonstrate how shocks which occur during the high stress regime typically produce a greater impact on the economy and discuss how policy responses to the occurrence of such shocks can be better guided.

Supervisor:
Emre Aylar

Authors:
Oskar Landgren
Jack Crooks

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1. Introduction

In this paper, we seek to contribute to the understanding of financial stress in the Chinese economy, both in relation to the dynamics through which the greater economy reacts to fiscal shocks in specific sub-sectors across differing stress regimes while also considering the process through which such stress accumulates and the potential implications for China's future economic development. We design a bespoke financial stress index to facilitate this process of analysis, drawing upon the expertise offered in a variety of academic papers to ensure that our approach fulfils the necessary requirements of accuracy and insightfulness, allowing for the cultivation of strong conclusions in which we can express our upmost confidence. As such, we consider a wide variety of previous work in order to develop a comprehensive, holistic understanding of both the inner workings of the Chinese fiscal system and the mechanisms guiding financial stress, with this process essential in aiding us in the adaption of the transmission vector autoregression model initially credited to Balke (2000). The model was conceived for use in scrutinising more developed economies to investigate the effects of fiscal stress in credit markets, however we have reconfigured the approach with particular reference to Afónso et al. (2011) to account for the specific conditions of the Chinese economy. We find robust evidence that the period in which fiscal shocks occur has strong implications as to the degree of effect they will have on the wider economy, with those occurring in high stress regime typically leading to far greater volatility across the observed markets. Furthermore, we demonstrate that excess financial can have a contractionary effect on GDP growth, whilst we also argue that the apparently cyclical nature of such stress combined with the transitory nature of China's economy may have negative implications for future growth prospects.

Given the apparent certitude of China's ascension to the ranks of the world's dominant economic superpowers, it is perhaps rather puzzling that there remain vast swathes of the domestic economy of which our understanding is as yet questionable. While it is undoubtable that the opacity of the Chinese political and economic system has contributed to this lack of clarity, it is equally troubling that amongst the majority of research which has been conducted, little appears to question the fiscal system's capacity to manage events in the case of damaging fiscal shocks, with very few of the papers focused on stress indexes considering the Chinese case. In the private sector, we were able to identify indexes constructed by both

Nomura[1] and Bloomberg[2] but upon deeper consideration these appeared to be extremely broad in conception and so we felt a more precise, targeted index would be better placed to evaluate presence and effects of shocks. The lack of previous research specifically focused on China is understandable given the recent decades have paid witness to an unprecedented and apparently unwavering growth trend, dictating an inescapable lack of conditions in which natural experiments into such shocks can be conducted. However, given such circumstances, we feel confident in expressing our opinion that this work fulfils a definite need within the current research landscape, as developing a full and cohesive understanding of the exact workings of the Chinese financial system, it's resilience to financial stress, and the government's ability to alleviate such stress through appropriate monetary policy become ever more important in our increasingly interconnected global economy.

Before expanding on our conclusions, we will continue Section 1 with a comprehensive overview of the body of literature considered in developing our understanding of the conceptual background of financial stress, the empirical models available and the specifics of the Chinese case. Following this we provide an overview of the data utilised and the methodology underpinning our approach in Section 2, offer a detailed explanation of the process through which our financial stress index was constructed in Section 3 and discuss the results of our statistical analysis and reflect on the inferences we can draw from our examination of the shock impulses in each of our dependant variables in Section 4, finishing with our concluding remarks in Section 5.

1.1 Literature Review

When looking to develop a more comprehensive understanding of this topic, it can be helpful to approach the body of literature in segments, building understanding of the separate strains of research upon which such a project is grounded before attempting to combine these into a greater cohesive conception. As such, we will first discuss previous works which contributed to our understanding of financial stress and how it can effect an economy before moving on to the literature covering the Chinese financial system, particularly in relation to financial stress, whilst also appraising papers dealing with the effects of financial stress on both monetary policy and emerging economies outside of the Chinese context. This will allow us to properly assess how the Chinese system's unique design can be seen historically to have both mitigated and exaggerated such effects across a variety of circumstances and financial conditions.

[1] Bloomberg Code: NMEICSI
[2] Bloomberg Code: CHBGRISK

The ideological lineage of financial stress can be traced back across the centuries, with the original motivation to define the concept arguably a direct consequence of the groundbreaking work of French academic Jean Charles Léonard de Sismondi, whose 1819 paper Nouveaux Principes d'économie politique provided the catalyst which would lead economists away from classical equilibrium theory and introduce the idea of systematic financial stress and periodic crises (Benkemoune, 2009). Prior to Sismondi's contribution, classical theorists had tended to denounce the existence of a business cycle and instead sought to blame financial stress solely on external influences, with military conflict foremost amongst them. However, with Sismondi's publication, in addition to that of related works by Robert Owen, 19th century economists began to accept the idea of natural fluctuations around a trend, with overproduction and underconsumption identified as endogenous periodical sources of such stress (Simpson, 2014). This would lead Sismondi to identify wealth inequality as the primary source of economic volatility and so formed the basis of calls to increase government intervention amidst the advocation of socialist principles, a development perhaps responsible for the marginalisation of such work by many of Sismondi's contemporaries in classical economics (Whatmore, 2002). However, following these initial advances, the French political economist Charles Dunoyer came to understand that these periodic crises could be reconceived under a greater framework of alternating cycles of boom and bust, seeking to interpret Sismondi's work in a manner which rendered it compatible with Jean-Baptiste Say's theories of political economy - under which the ability to adapt to the ever-changing nature of circumstances is paramount - and thus laying the groundwork for much of our current understanding of economic trends (Benkemoune, 2009).

It is such ideas which would go on to form the basis for much of Keynes' work on underconsumption while they were also co-opted by Karl Marx in his magnum opus Das Kapital, as well as his posthumously published work Theories of Surplus Value, which cited the increasingly volatile nature of the capitalist system and the subsequent severity of negative economic shocks as a key factor predicating a communist uprising (Sherman, 1967). Arguments in such a vein would latterly be countered by the Austrian School, with the work of Joseph Schumpeter vital in restoring legitimacy to the idea of the business cycle as a natural consequence of economic growth. Schumpeter built upon Clement Juglar's attempts to introduce a degree of specificity to both the length and circumstances common to the differing 4 stages of cycles to define the Juglar cycle according to four distinct periods (expansion, crisis, recession, recovery), showing how each stage was intrinsically linked to its immediate

predecessor and so periods of recession are vital to fuel innovation (Legrand & Hagemann, 2007). According to such principles, the Austrian school favoured a minimalist approach to intervention, arguing that overt government involvement could only exacerbated a crisis whilst downturns were typically seen to result from excessive credit issuance caused by a fractional reserve banking system, which in turn led to resource misallocation and malinvestment. This was a radical line of argumentation, fundamentally contrary to the Keynesian position necessitating political action as a means of stabilising following economic trauma. However, the narrow focus on endogenous causes as well as the dogmatic nature of the Austrian approach to economic science saw the school's view rejected by mainstream economists as a neo-classicist approach defined by strict faith in the counteractionary possibilities offered by the Phillips curve arose. For a time, this offered a degree of hope that the governments now possessed the tools to exert far greater control and ensure more stable growth. However, although the stagflation of the late 70's swiftly discredited such hopes while work by Friedman and Phelps demonstrated how inflationary expectations eventually contradict the Phillips curve over time (Gordon, 2018), the academic acceptance of the conception of a structural business cycle had entered a sharp decline. This was followed by the great moderation of the 80's and 90's, a period of steady growth which led Robert Lucas, the renowned macroeconomist, to declare 'the central problem of depression prevention has been solved' in a 2003 speech to congress (Lucas, 2003). This too would prove overly presumptuous as the global financial crisis ably demonstrated the spectre of recession was far from overcome. As such, whilst theories purporting to identify strictly periodical business cycles may remain unpopular, there has been a substantial drive within the research community to expand our understanding of the factors which can lead to recession. Consequently, we have witnessed a significant shift in focus to identify localised stress within the financial system as a key indicator of potential trauma, with switching models such as the TVAR model we opt to utilise typically seen to possess a greater degree of accuracy (Duprey & Klaus, 2017).

The renewed focus on fiscal stress has allowed for a broader conception of the possible causes of recession, allowing for both exogenous and endogenous sources rather than focusing on a specific doctrine while placing as much emphasis on researching occasions in which potential crises have been averted as those in which they have occurred. This has allowed for a greater 5 emphasis on the specific effects of such shocks, culminating in a greater understanding of the divergent channels through which fiscal stress can impact upon an economy. Meanwhile,

it has also paid witness to the development of new models through which we can better conduct such analysis, with the work of Balke (2000) remaining perhaps the most influential although the success of the Cardarelli et al. (2011) model in developing a specific financial stress index for the holistic analysis of a developed economy merits consideration. Equally notable is contribution of Chiu & Hacioglu (2016) - who analysed UK data using both a TVAR model and a Markov-switching VAR, concluding that both methods produce empirically similar results while financial shocks which occur in high-stress regimes lead to disproportionately severe output contractions – and that of Shahnazarian & Bjellerup (2015), who analyse Swedish data via the creation of a specifically designed structural VAR model in order to capture the disparate effects of four separate channels within the monetary transmission mechanism, succeeding in demonstrating and quantifying the link between the financial system and the real economy. Finally, but certainly relevant for our purposes, Lai & Lu (2010) constructed a stress index focused on the Chinese market, although this only considered the banking sector, stock market and foreign exchange market by using four variables and the equal-variance method.

Referring first specifically to the work of both Balke (2000), upon whom we will lean heavily in the methodology of our approach, the development of the TVAR regime switching approach offered a significant contribution which dramatically aided our ability to identify and isolate financially stressful events. Although Balke's original research focused primarily on scrutinising the effects of credit shocks under different regimes, thus neglecting to account for the analyse of additional markets (Li, 2010), the paper still offers a blueprint to adapt the model for ulterior purposes, with Afónso et al. (2011) providing a useful example of the applicability of the model to our case. They examine how changing market conditions affect the impact of a fiscal shock and how monetary policy can either exacerbate or subdue the resultant nonlinearities across a range of developed economies, utilising the threshold technique to discern between the separate conditions.

It is also interesting to note that much of this research has been conducted against the backdrop of the period of long-run steady economic growth defined by the 'great moderation' which has accordingly provided a fertile environment for the development of theory more applicable to the Chinese case given the lack of periods of outright depression. This leads to a key point which perhaps merits expansion, namely that given the Chinese economy has 6 experienced generation's worth of stagnation under communism followed by over three

decades of constant growth, upon considering the applicability of the recurrent business cycle concept it appears unsuited to documenting this experience. Conversely, financial stress appears to be an ideal tool to evaluate the robustness of the overall economy, as it allows us to isolate specific pressure points while the nonlinear impulse shock response will illustrate exactly how this pressure reverberates around the entire system. Having specifically examined the Chinese economy, Sun & Huang (2013) provide strong evidence suggesting that it is this pressure which acts as a natural identifier, or early warning system, for a potential recession. Additionally, Chen et al. (2017) examine the implementation process of monetary policy, finding asymmetries in terms of how asset price reactions differ in their sensitivity to tightening shocks and easing shocks respectively, while Kamber & Mohanty (2018) find that monetary policy shocks tend to have persistent effects across the banking and debt markets, with both suggesting that monetary policy transmission in China has become increasingly similar to that in advanced economies.

Furthermore, if we consider the business cycle according to it's strictly classical definition as a signifier of innovation driving an economy, we fail to capture one of the simpler but more important aspects of the differences between the Chinese case and the western developed economies upon which much of the foundational literature and understanding is predicated. That is that China is still a developing economy, admittedly more so in some geographic and economic areas than others but overall we can safely regard it as an economy which is still operating at a level far below its potential peak efficiency. As such, we can define its recent growth as catch up, in contrast to the frontier, cutting edge style growth of the western economies (Yusuf, 2012). This frontier growth is typically driven only by ground-breaking innovation, in the aforementioned Schumpeterian conception we see the idea of Kondratiev waves bringing new technology which in turns allows production to increase. These gains lose momentum over time and eventually tail off as ever smaller seams are mined and niches filled before malinvestment occurs as the marginal effect of participating is negated. This leads to a period of recession as capital is withdrawn before new innovation restarts the cycle (Ülgen, 2013). However, in the Chinese case the economy can benefit from the accumulated wisdom of those who have undergone such transitions previously, utilising foreign experience to guard against committing similar errors and so avoiding the periods of stagnation which can follow growth cycles. Research across a broad range of developing economies identifies similar trends, as Balakrishnan et al. (2011) adapt the Cardarelli model discussed previously 7 for the specific analysis of emerging markets, investigating the transmission of financial stress

from developed to developing economies, whilst Cevik et al. (2013) follow a similar structure to construct a financial stress index for transitional economies (Poland, Hungary, Russia, Czech Republic & Bulgaria), demonstrating the potential for financial stress to derail growth if not immediately resolved. Particularly relevant to our case is the work of Stolbov & Shchepeleva (2016), who modify the Balakrishnan approach to create an interlinked framework capable of modelling the effects of cross-country financial stress, before going on to show how both the Chinese and, to a lesser extent, the Indian economies display greater resilience to international turbulence, suggesting this may result from the scale of their domestic marketplaces.

Meanwhile, China possesses a number other discernible advantages in comparison to such economies, primarily in relation to the political system and the resultant control of the centre party. The implicit social contract of the Chinese state effectively secures the political status quo conditional on the maintenance of the current pace of economic development (Cook & Dmitrov, 2017). This control ensures the party is effectively unaccountable in the short term and so allows it to commit to long term economic planning in a manner which precludes many of the traps into which emerging economies can often fall. Although we will go on to show that the nature of this planning, particularly in the long term, tends to angle towards broad strokes rather than exhaustive detail, in situations such as the introduction of foreign investment the government can act in the interest of the whole without regard to individual or local considerations. Conversely, we have the example of the Kalecki notion of an electorally based business cycle, whereby political parties over-promise prior to election campaigns before under-delivering following victory, allowing the opposition to repeat the same tactic and so creating a cycle of poor governance (Nordhaus, 1975). This is a simplified version of a tangible situation which embroils many ambitious emerging economies, and so derails progress as inefficiencies abound. However, the political situation in China effectively insulates the economy from such a situation and so such an example represents further evidence as to the prudence of examining specific markets to detect financial stress, as the scale of governmental control may prevent such incidents from spreading throughout the greater economy.

This brings us neatly to our examination of the specificities of the Chinese case, as we seek to build our understanding upon solid foundations, clarifying the theological and ideological procession through which China has emerged as a functionally capitalist economic system 8

while retaining the political structure of the preceding communist regime. The advent of such a progression can be clearly traced back to the ascension to power of Deng Xiaopeng, which began under the stewardship of Chairman Mao before events following his death saw Deng seize control amidst the turmoil of the collapse of the gang of four and the brief premiership of Hua Guofeng. Deng, a former party favourite had been twice purged during the cultural revolution as his political practicality and progressive economic ideology led to conflict with Mao (Niu, 2012). However, given control in his own right he became free to enact policy reform initially designed to elevate the productivity of the less developed coastal regions and circumvent the probability of another period of famine occurring, which had been identified as a material danger. This ambition took the shape of the numerous reforms throughout the late 70's and early 80's as Deng took a multifaced approach to regeneration, encouraging targeted foreign investment via the newly implemented special economic zones, while also legislating for land de-collectivisation through the household responsibility system and consenting to the creation of township village enterprises, a key landmark in China's economic resurgence (Tisdell, 2008).

Indeed it was the success of these township-village enterprises which arguably drove China's transition to a more entrepreneurial society, as it was following Deng's 1989 'tour of the south' that he first witnessed the success of the policy in driving the local economy and began to understand the possibilities offered if such a evolution could be enacted nationwide. This led to a raft of further reforms designed to implement the so-termed 'socialist market economy, Chinese style', a system which aimed to capture the benefits of capitalist ingenuity while retaining the centralised political power structure (Zhao, 1993). As we will explain further in our analysis of each market, this led to dramatic changes across each section of the Chinese economy, allowing for private companies, recreating a stock and credit market, further opening the country to foreign trade and investment which in turn revolutionised the foreign exchange market and also transforming the banking sector. However, in order to latterly understand the decision making process underpinning the Chinese government's reaction to shocks and subsequent monetary policy, it is vitally important to understand the nature of the legislative process which led to this change. In effect, historical precedent suggests China's ruling party tends to enact change through a trial and error system, with policy innovation experiments - the TVE's representing one concrete example - initially conducted in specifically chosen regions before being rolled out for cross country use if successful (McMillan & Naughton, 1992). This tactic also defines the regimes approach to 9

sectoral legislative change, with the reforms to the banking system visibly conducted as small scale evolutions building upon the success of the last as opposed to one large scale shift. Meanwhile, China is equally open to withdrawing support for policies which fail to achieve their targeted aims, and in this the systematic lack of accountability present within the political system can perhaps be seen to have contributed to a culture of economic experimentalism, in turn facilitating the unprecedented growth from which the nation has benefited (Heilmann, 2008).

This lack of accountability can be seen as perhaps the key differentiating feature between the Chinese case and comparable developing economies in the modern age. Across the South East Asian Economic miracle - comprising of Japan's post-war recovery and the Asian tiger economies of the 1960's – the presence of a benevolent absolute power has been near constant trend, often taking the form of a well-entrenched dictator able to drive through policy change while operating with a singular focus to ensure comparative advantage is maximised (Gilson & Milhaupt, 2011). This is especially pertinent in China, and is particularly relevant in light of our discussion of business cycles given the Kalecki theory of politically motivated business cycles previously outlined. However, another aspect of the degree of government authority is the aforementioned culture of policy experimentalism which it creates, as this often defines the lopsided manner in which policy effects the domestic population. In relation to the construction of our stress index, this can lead to interesting questions pertaining to the relevance of including certain sectors as the distinct legislative environment ensures adopting a previously defined model wholesale will fail to account for the prominence and importance of these sectors to the wider economy. For instance, the majority of financial stress indices computed in recent years allow some consideration for the housing market given the increase in fears that overheating in this crucial sector will have widespread repercussions for the greater economy. It is immediately apparent that this fear is less rational given the peculiarities of the Chinese system, under which government price controls are near impossible to circumvent (Koss & Shi 2018). Furthermore, the housing market remains a quasi-political issue, particularly in light of the distinction between migrant workers – who move from their home province in search of greater opportunities – and those who choose to remain in the locality of their birth. Migrants are typically from the poorer or less developed provinces and in moving they relinquish many of their rights, opting against inclusion in the majority of welfare and social benefit programs and leaving the care of their familial agrarian plot to older relatives. Despite the apparent hardships they face, domestic migrants form a key

10 demographic of the Chinese labour force and the liquidity they bring to the labour market is vital to further economic progress (Chan, 2010). However, residual fears over maintaining the volume of manpower necessary to sustain agricultural production have averted any attempts to secure a systematic overhaul of the current arrangement resulting in a peripatetic population whilst also, returning to the original point, curbing house price growth through intervention in the natural mechanisms of supply and demand (Dreger et al., 2013). In this example we can see how the wholescale importation of a financial stress index originally conceived for use in a separate context is suboptimal in our case, and so we reiterate our belief that it is only through the cultivation of a specific knowledge of the Chinese system that such analysis can be properly conducted.

In its present incarnation, the Chinese state appears to be at what will come to be recognised as a central crossroads in its development. With the economic conversion towards a more liberalised entrepreneurial system well underway, transparency and accountability apparently increasing, international recognition of a truly global trading power coming in the form of ascension to the WTO as well as the overseas clamour for favour despite US antagonism, and an increasingly significant role in global affairs as the ruling party appears set to end decades of Chinese introspection, it appears as though China is preparing to transition from merely supplying the worlds demands to defining them. Following the influential flying geese model of Asian economic ascendancy originally ascribed by Japanese scholar Kaname Akamatsu in the 1960's, China appears set to evolve beyond the kind of low value added manufacturing typical of its early contributions (Nakagane, 2013). Meanwhile, the huge investment in education and research, as well as the substantial spillover benefits associated with the high levels of foreign direct investment (Ito, 2012), suggests that the state has ambitions to swiftly transcend the secondary stage limited to more technical production in order to begin to create products desired by both the expanding middle class of its own domestic market as well as those overseas. This may signal a near term move to a slackening of fiscal controls as the currency peg is loosened amidst the requirement to purchase the necessary raw materials while also serving the demands of the increasingly wealth population for improved access to overseas goods (Park, 2016). Managing such a transition is no mean feat, with the difficulty typified by the need to manage the near split between the accelerated coastal regions and the less advanced inner provinces, the majority of whom are still reliant on the artificially weakened exchange rate to allow local industry to survive (Sun, 2013). Throw in an increasingly volatile international political environment and it becomes apparent that the 11

successful supervision of such a procedure will require a highly attuned understanding of the exact mechanisms through which small instances of localised pressure within the system can swiftly become near unmanageable if incorrectly handled. As such, we believe that looking to develop a deeper reserve of knowledge regarding both the effects of financial stress and how these can feedback across the economy is necessarily vital to ensure the ongoing success of the Chinese development process.

2. Methodology

2.1 Data Overview

Before starting to delve deeper into the workings of the model we will use, we thought it may be helpful to offer a small overview of the data gathering process, both to assist with any further research but also to highlight the difficulties we encountered and demonstrate how these were mitigated. As such, we have provided in the appendix (see table 1) a comprehensive document displaying the source of each variable used within our econometric analysis, which we hope that this will prove useful in illustrating the inexact nature of econometric analysis in the Chinese case given the breadth of sources required. However, with regard to a few specific variables we felt it pertinent to address exactly how we sought to collate the information required. Firstly, with regard to GDP figures, the Chinese government currently publishes retrospective GDP growth figures on a quarterly basis. Given that the overwhelming majority of our data had been compiled on a monthly basis this presented us with a common question in econometrics, namely whether to convert our monthly data too quarterly or vice versa. The first option would ensure compatibility and avoid making theoretically baseless assumptions as to the nature of the GDP data we could not observe but would sacrifice a large amount of potentially illuminating information while the latter would require us to estimate the shape of the GDP curve across the quarter, a process for which we could not guarantee accuracy. We considered a variety of techniques which could potentially alleviate such a problem, most notably cubic spline interpolation, a common solution which would have allowed us to convert the GDP data whilst retaining a degree of accuracy as far as was possible. However, we ultimately felt that, given the overwhelming importance of retaining our ability to observe minute fluctuations in our dependant variables accurately, such a step would be inappropriate in our case. As such we have chosen to conduct our analysis on strictly quarterly data, deciding that ensuring the accuracy of our results was ultimately our first priority.

Secondly, it is important to highlight the issues regarding the compilation of non-performing loans data in China, particularly in the pre-2003 period. The non-performing loans ratio constituted an important aspect of our analysis of the financial stress within the banking industry, however the China Banking and Insurance Regulatory Commission only began to publish this data in the first quarter of 2003 following reforms to the banking industry which we will latterly cover in greater depth. In order to resolve this problem, we uncovered a

number of academic papers focused on estimating the level of non-performing loans within the Chinese banking system in the pre-reform period and decided to include the estimates presented in our own analysis. However, there were two main drawbacks to this approach relating to both the data structure and concerns over the accuracy of the data. With regard to the structure, the data we were able to locate was only compiled on a yearly basis, an issue which was perhaps to be expected given the opacity of the Chinese banking system during this time and the difficulties this presents for such analysis but still problematic. Here, we did decide to utilise the cubic spline method, producing from the yearly estimate a value for each month within that year and so avoiding discarding the period from our analysis altogether. We felt that this represented a more acceptable use of the technique, primarily due to the fact that observing minute fluctuations in the data in question was less important than identifying the general trend in this case. Turning to the accuracy of the pre 2003 information included, we have sought as far as possible to mitigate any potential concerns by referring only to accredited academic works when attempting to locate data approximations and choose to include the information sourced from the Xiao (2005) paper as this proved not just reputable, but also to be in line with the majority of estimates. However, it is important to note that there were also several papers which suggested that though these may be accurate approximations based upon the official data available, the real figure may be far higher owing to the unverifiable nature of many of the soft loans undertaken during this period (Elliot et al., 2015). As such, we decided to proceed with caution, including this portion of the analysis but retaining a degree of wariness before drawing overly confident conclusions from the results.

This brings us neatly to our final short point on data, namely the general culture of mistrust surrounding even easily obtainable figures available from government sources. As the pressure to sustain the GDP growth rate builds, there are suggestions that it pays to adopt a sceptical approach to such figures, especially given the lack of transparency within the data gathering process (Koch-Weser, 2013). This applies not just to GDP figures but across the board as the party has been dogged by accusations of manipulating official figures, both to hide the soft loan burden and to disguise the growing corporate debt problem. Meanwhile, in sectors such as the foreign markets, government manipulation is in place to maintain a currency peg, reducing the quality of the data available and further exacerbating the need for caution when analysing results.

2.2 Threshold Variable Autoregression Model

As detailed, we are primarily focused on uncovering the non-linearities in the transmission of financial stress in the Chinese system, as only through the identification of such periods can we begin to examine the success of the specific policy response each warranted. In order to do so, we will adopt a two-regime TVAR approach as proposed by Balke (2000). This model possesses multiple characteristics that make it appropriate for our purpose. The TVAR model can be seen as a fairly simple method to capture the existence of nonlinearities such as the presence of various equilibria as well as asymmetries between responses of shocks. As the effects of the shocks are dependent on both the initial conditions along with the sign and size of a shock and the impulse response functions are no longer linear, it is possible to identify the disparities between the effects on monetary policy and fiscal development under different financial stress regimes.

Furthermore, the TVAR model allows the variable responsible for defining the regime, in our case the Chinese financial stress index (CHNFSI), to be an endogenous variable which is part of the VAR. This allows for potential regime switches after a shock to each variable, meaning that a fiscal policy shock can increase the degree of stress and so have a negative effect on the outlook of economic growth, and as a consequence the GDP growth can become negative due to a fiscal expansion (Afónso et al., 2011).

The TVAR model is estimated as follows:

$$Y_t = u^1 + A^1 Y_t + B^1(L)Y_{t-1} + (u^2 + A^2 Y_t + B^2(L)Y_{t-1})I(c_{t-d} > \gamma) + \varepsilon_t$$

Here, the dependant variable Y_t is a vector with the dimension $n\ x\ 1$ of the endogenous variable, which in our case refers to GDP growth, inflation, the Chinese interbank lending rate (CHIBOR) and the constructed Chinese financial stress index (CHNFSI). We will explore the theoretical background of the construction of the CHNFSI later but specifically regarding the methodology, we calculate this variable by summing several sub-indices via an equal weighting method, chosen as it allows us to gain a broad understanding of the entirety of the Chinese economy, a more extensively explanation for this choice will be presented in chapter three. The sub-indices are designed to gauge the instability of their respective markets, which in our case are namely; the banking market, stock market, foreign exchange market and debt market.

In the model, $B^1(L)$ and $B^2(L)$ are lag-polynomial matrices while ε_t denotes the error term i.e. the structural disturbance of the estimation. The I is a binary indicator variable which can take a value of 1 or zero. Specifically, it will be 1 if the lagged value of the threshold variable (in our case the CHNFSI, denoted by variables (c_{t-d}), takes an higher value than the critical threshold value γ, or the value of 0 otherwise. As a result the indicator variable works to effectively divide the regimes in two according to the threshold value, thus allowing the model to shift between regimes endogenously.

The variables A^1 and A^2 mirror the 'structural' concurrent link during the financially stressful regime in relation to the non-financial stressful regime separately. In line with the Balke (2000) study, we will apply a recursive identification scheme, which Balke refers to as a structural threshold VAR-model, this recursive identification ordering scheme is thus compiled in the following order: GDP, Inflation, CHIBOR and the Chinese financial stress index (CHNFSI). In this case, the use and specific construction of the recursive scheme also follows numerous previous studies, for instance Leeper (1996) and Gertler & Gilchrist (1996) and in choosing to conduct the analysis in such a fashion, specifically while allowing the financial stress index to be the last variable in the structure, the model allows the macroeconomic variables to have concurrent effects upon each other, according to the recursive order system. This means that by implementing the recursive order we can indirectly choose which of the macroeconomic variables can respond to one another. For example, the recursive ordering in our study will have GDP as the first variable, and thus it will only be effected by the other variables within the system after one or two lags respectively (Afónso et al., 2011).

It is also important to note that, given the model effectively allows us to study two different regimes simultaneously, it so follows that they are characterized by different parameters as appropriate. In practice this means that with reference to the regime where $I(c_{t-d} > \gamma) = 1$, the restrictions of the model becomes $u^1 + u^2$, $A^1 + A^2$ and $B^1(L) + B^2(L)$. Equally, in the case where $I(c_{t-d} > \gamma) = 0$ the model's parameters convert to u^1 , A^1 and $B^1(L)$. To better illustrated this point, in a scenario where γ is known there would be no requirement for the model adapt in order to account for the two different regimes and so we could test the effect of the threshold with an F-test under the null-hypothesis H_0: $u^1 = A^2 = B^2(L) = 0$. However, as our threshold value (γ), is not known, and is not defined under the null, the model testing in

our case contains non-standard inference and the threshold value must be endogenously estimated (Afónso et al., 2011).

Therefore, when testing our model, the TVAR model is first estimated by using the OLS method for all potential values of γ, again following Balke (2000), while in order to avoid overfitting the model we restrict the potential threshold values so that a minimum 15 percent of the observations and the parameters are within each of the two regimes. After that, for each of the potential threshold values estimated, a Wald Statistic test will be computed, which performs a test under the hypothesis that there is no threshold effect.

Subsequently, the model will use three different statistic tests. The maximum value of the Wald-statistic also called sup-wald, the average value of the Wald-statistics also called avg-wald and the sum of the exponential wald-Statistics also called exp-wald. In order to interpret these statistic tests, we compare them against the simulated empirical distribution that Hansen (1996) proposed, thus giving us the value that maximizes the log-determinant for the residuals. This is value is also the estimated threshold value.

2.3 Nonlinear impulse shock response

If we consider first a linear model, it is relatively straightforward to understand that the impulse responses in such a case will remain constant over the given time period, simply because the covariance structure does not vary over time. Additionally, impulse responses in a linear model can be derived directly from the estimated coefficients and the estimated impulse response shocks are thus correspondently symmetric in terms of size, persistence and sign (Afónso et al., 2011).

However, when moving on to discuss the nonlinear model, the complexity inevitably increases given we cannot repeat such assumptions as the same properties will not necessarily hold (Koop, Pesaran & Potter, 1996). In a typical nonlinear case, if the threshold vector autoregression model is accepted under the null, we can then begin to appraise whether the economic dynamics diverge across the different regimes and then examine the size, persistence and sign of an impulse shock response function to see if they differ from one regime to another. One such method to evaluate the asymmetries between the regimes and study the shocks effect in financial stressful times is to conduct a linear impulse response conditional on each of the regimes.

However, as the impulse response function is conditional on a specific regime when calculated, the indirect assumption for the function is to stay in a particular regime throughout the whole impulse response function. This means that, in the general case, the size and sign of the structural shock will be constant and symmetric over time, and consequently the covariance structure will not vary (Afónso et al., 2011).

In our case, we allow the Chinese financial stress index (CHNFSI) in the threshold vector autoregression model to be simultaneously affected by the other variables in the model, meaning that a shock to any of the variables within the model could bring a shift in the value of the threshold variable. That may cause the model to shift between regimes, which could in turn lead to the model frequently shifting between the regimes over the boundary of the impulse response. Consequently, a nonlinear impulse response function where the regimes is allowed to endogenous shift might be more appropriate (Calza & Sousa, 2005). The nonlinear impulse response function in contradiction to the linear impulse response function is more complex, and is given by the following function:

$$Nonlinear\ Impulse\ response\ function\ = E[Yt + k\ |\Omega t - 1, \varepsilon t\ ] - E[Yt + k|\Omega t - 1]$$

In the function, $\Omega t{-}1$ denotes the data set at the given time t – 1, and εt is the exogenous shock. The functions design indicates that we have to condition on the sign and the size of the shock, with consideration to the history of the variables in the model (Balke, 2000).

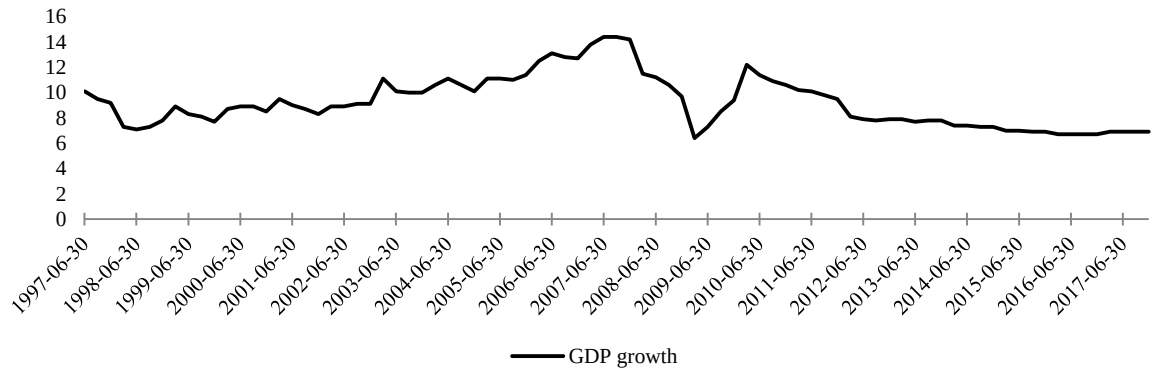
Moving on to look at the conditional expectations from the nonlinear impulse response function, which are given by $E[Yt{+}k\ |\Omega t{-}1,\ \varepsilon t\ ]$ and $E[Yt{+}k|\Omega t{-}1]$ and must be estimated while simulating the model, according to the estimation procedure presented by Balke (2000): Firstly, to be able to create the simulated forecast series, we draw the shock effects from the starting period 0 to q of the residuals of the estimated threshold vector autoregression model and thereafter for each respective initial value of the residual, which means that each point of our data sample is utilised through our model. After that we condition the resulting forecast series on the specific sequence of the initial values and the shocks and by doing so the simulation will return one given estimation of $[Yt{+}k|\Omega t{-}1]$. Following this, we repeat the simulation conducted in in the first forecast using the same residuals and initial values. However, we modify the function to let the shock of the focused variable be fixed to ± 2 standard errors or ± 1 standard errors at the given time t = 0. Thus, the second simulation returns one estimate of the function $[Yt{+}k\ |\Omega t{-}1,\ \ ]$.

Next, we compute the difference between the first and second estimation, which returns one simulated value for our nonlinear impulse response function. In order to ensure that any potential asymmetries which could arise due to sampling variation in the drawn shocks are removed, the procedure will be computed 500 times. As a result, the average of this 500 nonlinear impulse response function calculations provides our estimated nonlinear impulse response function. (Balke, 2000; Afónso et al., 2011 & Atanasova, 2003).

3. Economic Variables and the Chinese Financial Stress Index

3.1 GDP Growth

Figure 1: GDP Growth 1997 - 2017



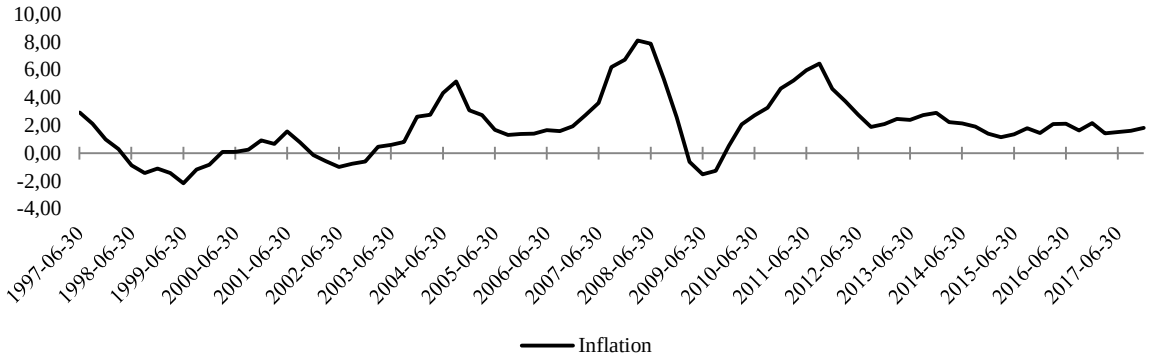
First among our dependant variables is GDP growth, of which consideration is vital to any analysis of the Chinese not just as it provides perhaps the most accurate picture of the nation's output but because the Chinese government has so fiercely based the legitimacy of its own premiership upon maintaining relentless economic advancement as measured by this figure. The continuation of high GDP growth has thus become almost a proxy for the aforementioned implicit social contract of the Chinese state, and so were any unexpected economic shock to impact negatively upon this, it could risk not just the nations fiscal health but also forecast the fraying of the political relationships which uphold the one party system. As such, through cultivating an understanding of how financial stress reverberates throughout the domestic economy, we become better placed to comment on exactly how GDP growth has previously reacted in the case of such shocks, while we can also accurately identify specific situations in which the accumulation of financial stress has negatively affected GDP growth and thus increase our understanding of how the state typically reacts from a monetary policy perspective.

As we can see from the graph, Chinese GDP growth has been consistently positive throughout the period of our analysis and indeed for a long time prior to our chosen period of investigation. While the rate of growth did experience a substantial dip following the global financial crisis, it swiftly recovered to near pre crisis levels within a matter of months. However, growth rates have been in decline since this period of recovery, affected no doubt by a weaker global economic environment in which most major economies have been beset by low growth and periods of recession. Equally important in the post crisis period though, is

understanding that as we have discussed, China is in a period of managed transition between 'easier' catch up growth and the notionally harder to achieve frontier growth. As much of the more attainable progress has already been achieved, it is to be expected that growth will no longer reach the highs of 10% annualised. Nevertheless, it is enormously important that in spite of such slowing growth rates, which can be forecast and - if effectively communicated to the domestic population – should not hamper the governments ultimate mandate of transitioning to a world economic power, that growth rates do not turn negative, indicating a period of recession, as in such a scenario the political situation could quickly turn more volatile.

3.2 Inflation

Figure 2: Inflation 1997 - 2017



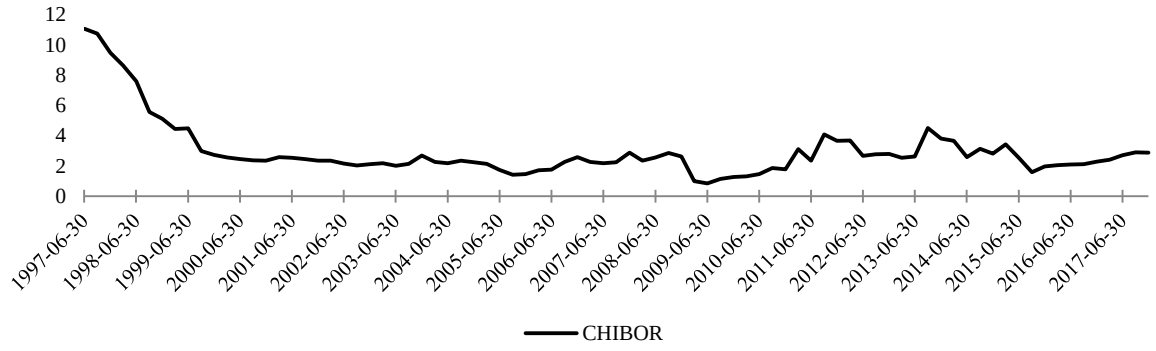
We have also chosen to include inflation as a dependant variable, believing that this will offer a valuable insight into the both the health of the greater Chinese economy and also the nature of the GDP growth we have accounted for, particularly important given the well documented complexities of the relationship between the two. Although the vast majority of economists are of the opinion that some inflation is necessary for economic growth and stability, there is much debate as to what exact level constitutes the ideal. The Chinese government, in contrast to many developed economies, does not publicly discuss a specific inflation target, with the maintenance of growth appearing to take precedence. However, although to an extent a degree of inflation can be seen to facilitate this growth, in order for it to translate into tangible progress inflation must be kept in check and so understanding how it reacts to shocks amidst financial stress is of the upmost importance to policymakers.

Turning to the graph, we can see periods of low to negative inflation in the early years, supposedly the result of depressed economic activity in the immediate wake of the Asian financial crisis. Following this, inflation increases in the pre-global financial crisis years,

peaking circa 8% immediately prior to news of the situation breaking. This again can be broadly explained by the level of economic activity, with the unprecedented growth in GDP contributing to inflationary pressure. As an understanding of exactly how serious and widespread the fallout from the trouble in the American markets would be increased, Chinese inflation falls into negative figures, resulting from the belief that the situation abroad would lead to a reduction in trade. However, inflation rebounded to a localised peak around 2011, with such fears failing to translate into a permanent large-scale reduction in trade and the European sovereign debt crisis producing far less trauma in the Chinese markets while in the period following this we can see inflation stabilises at around 2%, remaining at those levels consistently as GDP growth slows slightly.

3.3 CHIBOR

Figure 3: CHIBOR 1997-2017



Our final dependant variable is CHIBOR, or to give it its' full form, the Chinese Interbank Offered Rate. CHIBOR measures the average interest rate at which China's banks lend money to each other on the interbank market, with higher rates signifying a lack of trust in the banking system as it suggests that the lender judges the risk of default to be higher. As such, CHIBOR fulfils two key functions; firstly, it provides a strong gauge of macroeconomic and liquidity conditions within the Chinese financial system, and so assessing stress levels in relation to this indicator allows us to gather valuable information as to how key players within the domestic financial industry assess its health. Secondly, CHIBOR also provides a crucial building block for the pricing of financial assets and therefore periods of relative stress or calm within the CHIBOR market will have repercussions throughout the financial sector, ensuring that proper observance of this variable will allow us to better judge the performance of the economy as a whole.

As we can see from the graph, in our period of study CHIBOR was at its highest levels in the early period of 1997 – 1998. This is consistent with what we would expected for a variety of reasons, primarily given our understanding of the reforms enacted in the Chinese banking system which were targeted at removing a degree of opacity from the system and so duly increasing trust as a result, whilst the very concept of an interconnected banking system was fairly new in the earlier period and so approaching the interbank lending system with a degree of caution is understandable. However, we can also see that this period also saw the height of the Asian financial crisis under which whole governments fiscal capacity to meet obligations came under stress, further exacerbating the perceived degree of risk complicit in lending money in Asian markets. Following this period CHIBOR appears consistently calm in comparison as the market matures, with the next period of identifiable stress appearing concurrent with the European sovereign debt crisis. That CHIBOR actually decreased during the global financial crisis is an interesting finding, suggesting perhaps that the perceived risk of lending domestically actually decreased as a comparative result of the trauma overseas. Otherwise, we must also consider the possibility that governmental pressure was placed on the banking system to ensure adequate liquidity in the system. This was followed by increased stress in the post crisis years which could result from a number of factors, from the increasing preference to invest overseas in apparently riskier large scale capital projects – such as the Pakistani economic corridor (Mustafa & Zafar, 2017) – to increasing fears over the extent of the Chinese shadow banking sector and commercial debt burden. One further take away is that the slight but sharp dip in stress levels in the late 2015 period directly coincides with the Chinese stock market fall, providing further fuel to the notion that the government is willing to excerpt pressure to ensure appropriate stability and liquidity in the case of fiscal shocks. As Porter and Xu (2009) explain, although CHIBOR is nominally independent both the lending and deposit rates are controlled under state regulation, diminishing the ability of the market determined CHIBOR rate to act as an independent price signal.

3.4 Financial Stress Index Overview

Upon initial consideration of the various options abounding in model selection, it quickly became apparent that only through opting to design a bespoke National Financial Stress Index for China's Financial System (CHNFSI) would we be able to achieve the functionality necessary to account for the specific complexities of the Chinese economy. In particular, when referring to the divergent strands which combined constitute the domestic financial system, it is necessary to account not solely just for domestic pressures, but also for foreign

influences which can equally lead to stress. To guide the construction of this index, we referred to the methods detailed in a variety of papers explored in the literature review before coming to the realisation that there were two main elements which would go on to define our choice of model, namely the weighting method and variable choice.[3] Regarding the weighting method, the various papers provided numerous potential frameworks, encapsulating everything from equal-variance weighting to variable weighting approach and equal weightings Consideration of these possibilities led us to consider the potential drawbacks and benefits of each approach before identifying the equal-weighting method as the best fit for our purpose for two crucial reasons. Firstly, using equal-variance weighting allows us to gain a broad understanding of the entirety of the Chinese economy simultaneously, rather than risking sectors which display less dramatic variance being drowned out amidst greater noise from the more volatile components. Furthermore, it also facilitates the inclusion of variables which we observe for a shorter time span, awarding them equal representation in the index during the period for which the data is available and thus counteracting a potential problem which arose during the construction of the debt market sub-index which we will go on to explore in greater depth. In our choice of this model, we followed the process of Shahnazarian & Bjellerup (2015) who incorporated the equal weighting method into their design of a Swedish financial stress index. Our variable selection process is also closely linked to that identified in this paper but here Shahnazarian & Bjellerup can be seen to follow Balakrishnan et al. (2009), before adapting the model for specific use in relation to the Swedish financial system by including a variable representing mortgage spread in the debt market sector.

When considering variable choice we approached the question from a ground-up perspective, understanding that the variables included in the index ought to cover the main components of the financial system within the country and so seeking to build a solid understanding of the historical background before considering the specific context of each sector. As mentioned, in this element we followed Balakrishnan et al. (2009), who constructed a financial stress index via equal-variance weighting to evaluate emerging economies which included five different sub-indices selected to cover the broad effect of the financial system in markets including the banking system, stock market, foreign exchange and debt market. We have drawn influence from this paper while also looking to adapt the specific choice of variables to better fit our particular purpose, with the resultant construction of our financial stress index designed to

[3] We have provided a more expansive illustration of each method considered while constructing our stress index in table 2 of the appendix for greater convenience

account for all the disparate segments of the financial system and so better gauge the severity of financial instability in China.

The index comprises nine variables which in turn cover four markets: namely banks risk spread, non-performing loan ratio and loan-to-deposit ratio for the banking industry; the shanghai stock market index for stock markets; exchange rate and foreign reserves for foreign exchange markets; and risk spread, sovereign spread and corporate debt for debt markets. These four markets can be seen to account for the near-entirety of the financial sector and so the model is thus capable of allowing for a comprehensive analysis of the effect of financial stress on both monetary policy and the greater business cycle.

3.4.1 Banking Sector

In spite of the progress China has made towards the adoption of greater transparency since the liberalisation of the economy in 1992, the government has ensured the banking sector remains under tight controls, whilst its convoluted internal workings can still appear impervious to outsiders. This is undoubtedly the result of design rather than happenstance, as the system can be seen to fulfil a dual role within the economy. The state initially founded the banks in order to provide a degree of liquidity to the financing of both key economic sectors and bespoke infrastructure projects, whilst today the banks have expanded their offering to everything from providing personal financing to investment management their legacy still forms a vital role in defining their current form.

However, it is perhaps important to note here that there exists a large informal lending sector in China, with the culmination of ‘guanxi’ or good relations typically seen as imperative to securing credit (Yin & Matthews, 2017). This culture was fostered under the communist era as personal lending was driven underground and flourished following the introduction of the township-village enterprises as a more entrepreneurial society gave rise to small networks of illegal private firms, which relied on a system of clustering, whereby credit was often extended by business partners, in order to survive outside the formal system (Han, 2009). Although certain studies have attempted to estimate the extent of this market, we believe such calculations are inherently unverifiable and so have opted against including them in our index. Nevertheless, it is important to understand the role of guanxi in the domestic credit industry as it can also influence commercial lending and provides a useful example of the culture of unregulated lending within China.

When computing the variable designed to reflect financial stress within the banking sector (BankCHNFSI) three different measures are included: the risk spread, the non-performing loans ratio and the overall loans-to-deposit ratio, all of which are weighted according to the equal weighting method. Of these, the risk spread represents the spread between the risk-free and risky rate, and reflects the gap between the outlook of default risk and the interbank liquidity limitations. The interbank risk spread is calculated as follow:

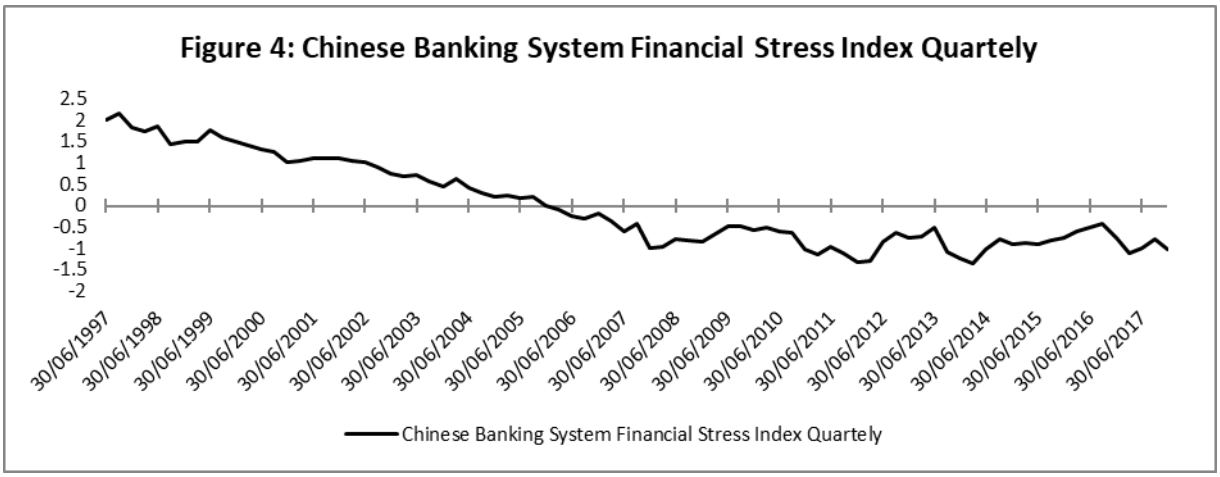
$$Interbank\ risk\ spread = L_t - TBR_t$$

Where L_t denotes the three month Chinese interbank borrowing rate and the TBR_t denotes the three month government bond rates. By including these variables, we account for any volatility in the levels of trust in the Chinese fiscal system, indicative of any beliefs pertaining to weaknesses in the system. This is a useful measure which functions in much the same way as a description of consumer confidence, displaying how confident banks are in the liquidity of their peers and bond holders are in the ability of the government to manage inflation.

The second variable included is the non-performing loans ratio, where we have chosen to use the non-performing loan ratio within state-owned commercial banks as a proxy representing the non-performing loans stress within the greater banking sector. Such an approach is seemingly reasonable given the scale of such institutions and the resultant extent to which they dominate the capital structure within the banking industry in China. With regard to non-performing loans, we have already discussed the difficulties in locating data for this variable prior to the banking reforms carried out in the post millennium period, as well as the belief prevalent in some quarters that even the now available official figures greatly underestimated the ubiquity of such loans in China. In the years prior to 1994 budget reform, the Chinese government operated under a quasi-federal system, whereby each region was faced with a hard budget constrain which it was required to meet, encouraging local officials to promote entrepreneurial activity in their locality (Jing & Zou, 2003). However, post 1994 this hard budget constraint was relaxed as a soft budget constraint became commonplace, theoretically in order to extend credit to local government infrastructure projects or inject capital into flailing state-owned enterprises. The state would latterly reduce the availability of such funding as part of a greater effort to introduce reform and international accountancy standards to the banking sector, an account backed up by our data as we witness stabilisation in the industry in the post 2003 period as the reforms begin to take hold. However, this program of institutionally lax financing was re-extended following the global financial crisis as the

Chinese government sought to insulate the domestic economy by providing capital to state-owned enterprises, which they were then responsible for disseminating. It has been suggested that the extent of this undocumented debt pile could result in serious repercussions for the China if left unchecked and many academics identify this issue, along with the commercial debt industry discussed in section 3.4.4, as a potential flash point in the years to come (Elliot et al., 2015). However, as much of this credit extension was purportedly carried out off book, our model fails to account for the resultant volatility in the banking sector and we should be mindful of this when conducting our analysis of the results.

Finally, we have also sought to examine the effect of volatility in the overall loans to deposit ratio, which is typically used to measure the default risk faced by the Chinese banks and their constraints in respect to capital. This measure provides an inside into the liquidity available within the banking sector, important for our purposes as it neatly illustrates the ease of access to capital which can illuminate the degree of flexibility with which companies in the domestic economy operate.



As we can see from the graph, stress in China's banking sector has exhibited a near constant decline during our period of investigation, with highs in the pre millennial years accounted for by the volatility inherent in the economic transition, the effects of the Asian financial crisis and the domestic banking crisis which took place circa 1998 (Laeven & Valencia, 2008). Stress levels then decreased gradually from this peak following the introduction of the aforementioned reforms, which is much as we would expect from our readings. The stress index does describes a significant drop in stress levels from 2007 onwards, which would appear to be at odds with the conventional wisdom given the worries related to the soft loan program. However, as these are unlikely to have been denoted as non-performing at this stage and will likely also have been offered at favourable terms it becomes clearer how the stress

index may fail to capture their effects, while an overall reduction in stress levels may also be attributable to the improvements enacted in other parts of the banking system.

3.4.2 Stock Market

Regarding stock markets, it is important to first note that there are currently two fully functional exchanges operating in China, namely the Shanghai Stock Exchange, officially opened in 1990, and the Shenzen Stock Exchange, opened in 1991. Both exchanges were initially conceived primarily as vehicles to provide further financing for ailing state owned enterprises, with opportunities to list for private enterprise restricted and although the exchanges have since outgrown this remit and today represent an integral part of the Chinese economy, they remain disproportionately comprised of such companies. Of the two exchanges, Shanghai is more established, being both marginally older and home to typically larger firms. It has also benefited from close links with the neighbouring Hong Kong Stock Exchange, aiding growth as the platforms work together and share relevant information. Although the stock market does now allow foreign participants in both share classes following a 2001 reform, such interaction is heavily restricted and so many Chinese firms have chosen to operate with dual listings, meaning they concurrently offer both A and B class shares, of which the A class is denominated in Renminbi and typically trades at a slight deficit to the foreign currency denominated B class (Carpenter & Whitelaw, 2017).

Despite their current standing amongst the world's largest exchanges, the relative youth of China's stock markets means they are as yet less ingrained in Chinese society and so do not play a particularly prominent role in the Chinese economy in comparison to the U.S. example, with property, wealth management products and bank deposits representing a far greater proportion of domestic investments with only about seven percent of urban Chinese owning stocks (Carpenter et al., 2018). Furthermore, whereas U.S. companies are heavily dependent on equity financing, in China a far smaller proportion of the total body of corporate financing is funded by equity, demonstrating the manner in which Chinese corporations rely far more on bank loans and retained earnings. Ultimately, this can at times assist fiscal policymakers as China's economy remains relatively protected from the disruptive flows of the stock, but also ensures companies remain limited in terms of the financing opportunities available, a factor that can inhibit overall economic growth.

Meanwhile, government interference and manipulation, particularly in the form of capital controls and IPO restrictions, remains widespread and the ruling party has shown a residual

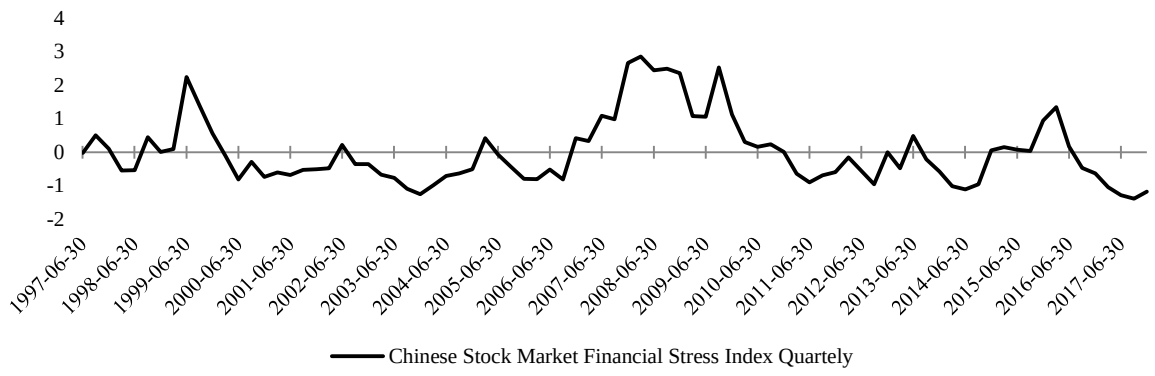
willingness to act in the face of extreme market fluctuations, with the restricted trading implemented in January 2016 the most recent example. For our purposes this is inconvenient given the difficulties inherent in assessing the volatility and resultant stress in a marketplace which effectively enters shutdown when such stress peaks.

To measure the systematic stress and the risk within the Chinese stock market, we measure the volatility of the stock index in the Shanghai stock market, and estimate it with a GARCH (1,1) model, following the process adopted by Bollerslev (1986). The GARCH (1,1) is calculated:

$$V_t = C_0 + \theta X' + \varepsilon_t, \varepsilon_t \sim IID(0,1)$$
$$\sigma_t^2 = c + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2$$

In the model, V_t denotes the monthly change in the Shanghai stock market index. And the σ_t^2 denotes the standard deviation in the stock market.

Figure 5: Chinese Stock Market Financial Stress Index Quartely



Upon examining the graph, we can see that the stock market financial stress index manages to identify key periods of turbulence which coincide with those we would expect from our understanding of the historical circumstances at each point in time. Specifically, we can see stress in the stock markets peak in the late 1998 to early 1999 period, which follows the Asian financial crisis, in the 2007 period following the global financial crisis, and again in 2015 following the Chinese stock market unrest. This suggests that the index performs as we would hope, managing to isolate specific time periods which exhibited excessive financial stress and so assisting us in our further analysis.

3.4.3 Foreign Exchange Market

Defining the foreign exchange market in China is a rather fraught process given the implicit difficulties in looking to identify volatility in the currency market in an economy which pegs its exchange rate. Although this peg has been strictly maintained, it has witnessed devaluations over time, significantly in 1994 and 2005 as the government sought to manage the cost of purchases from overseas (McKinnon & Schnabl, 2014). However, if we step back and consider this approach, we can see that although the currency remains pegged, the terms which define this peg have undergone various shifts in recent years, with the strict US dollar peg having been replaced by a basket of currencies, of which the weightings remain unknown, under 2006 reforms. Additionally, the Renminbi is now allowed to operate a partial flotation, albeit with the disclaimer that as it approaches either the upper or lower limits of the terms set, the state will artificially weaken or strengthen the currency to retain control. As mentioned, there is a suggestion that as China's economy transitions away from the high volume, low value model under which it has been so successful, demographic pressures may lead to further loosening of currency related fiscal controls (Park, 2016). As such examining how such cases have been handled previously should provide us with a guide for how such a change may be implemented in future, while examining the nonlinearities in the transition of such a shock should provide a good basis for understanding how this move would affect the wider economy.

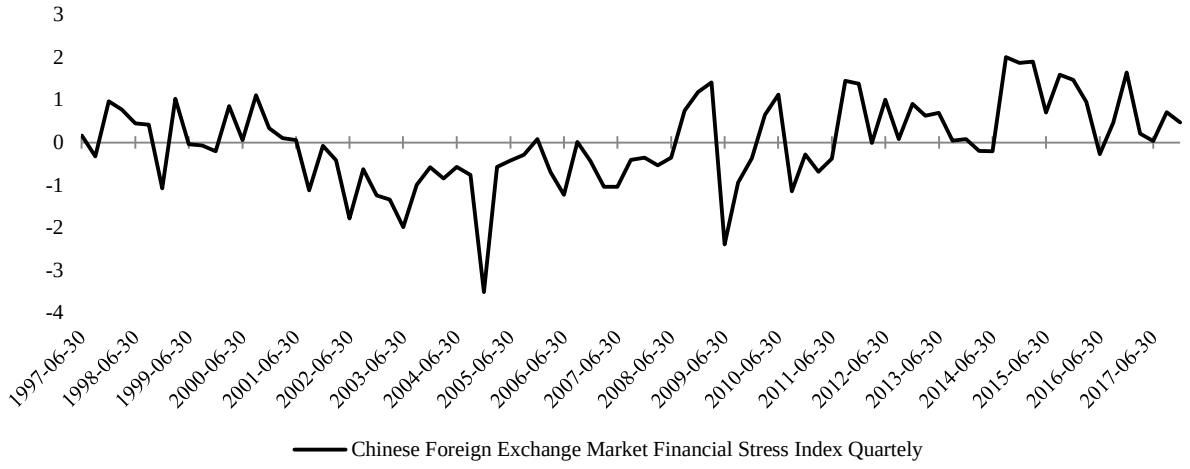
Meanwhile, by including a variable for foreign exchange reserves, we are able to examine the theoretical security of this peg, as well as develop an insight into the greater government foreign policy, as the large scale purchase program of such reserves is typically understood to act not just as a support to the renminbi, but as a hedge for the entire financial system. As China's government is the major stakeholder in almost all the nation's banks, it assumes the ultimate responsibility for any debts they may accrue. As such, the extensive reserves act as a bulwark to ward off undue pressure from the financial system, providing assurance that the state is capable of fulfilling its obligations in times of fiscal trauma.

The foreign exchange market stress (EMCHNFSI) is calculated as a function of its volatility, following the method utilized by Balakrishan et al. (2011) and is defined in the following way:

$$EMCHNFSI = \frac{\Delta e_t - \mu_{\Delta e_t}}{\sigma_{\Delta e_t}} - \frac{\Delta RES_t - \mu_{\Delta RES_t}}{\sigma_{\Delta RES_t}}$$

As we can see in the model, the variable Δe_t denotes the monthly change in the real exchange

Figure 6: Chinese Foreign Exchange Market Financial Stress Index Quartely



rate while ΔRES_t denotes the monthly change in the foreign reserves, μ_x denotes the average values and σ_x denotes the standard variance of the both variables.

The resultant graph paints a picture of high volatility, with the 1997 Asian financial crisis and the 2008-09 global financial crisis combined with the ensuing European sovereign debt crisis all causing dramatic fluctuations in the index. Meanwhile, in recent years the stress has also markedly increased, possibly resulting from the sharp decrease in the accumulation of foreign reserves. Questionably, the 2005 currency devaluation and the government's 2006 declaration of a floating exchange system do not appear to have resulted in heightened stress suggesting that the acceleration of foreign reserve accumulation during this period may have drowned out the volatility in the real exchange rate, particularly likely when we consider that such changes, though unexpected, were not particularly large in scale.

3.4.4 Debt Market

Although the Chinese government bond market is now among the world's largest and most actively traded, there are a number of specific issues which arise when attempting to evaluate the debt market and it is important to first highlight these before moving on to a discussion of the methodology of computing this variable. The primary constraint is perhaps the difficulty in accumulating reliable historical data, exacerbated by both the relatively recent introduction

of treasury bonds into the government's fiscal arsenal and the comparatively diminutive nature of the Chinese bond market in the years immediately following its introduction. Historically, the issuance of Chinese government bonds was terminated in 1950 following the communist uprising and would not be resumed until 1981 as soliciting additional funding for construction projects became a priority matter. Initially, this bond market took the sole form of a primary market, with issuance conducted via an administrative allocative process. Secondary trading would later be introduced in 1988 and established nationwide in 1990 following the creation of the Shanghai and Shenzen stock exchanges.

Subsequent developments included experimentations with an underwriting system in 1991 and the creation of a primary dealer system in 1993 as the government sought to liberalise the marketplace amidst its embrace of the capital creation possibilities inherent in a fully functional bond market. However, the bond futures market was suspended in 1995 as scandal erupted over the illegal short selling of government bonds, with a new raft of legislation introduced to restrict off-exchange trading. The scandal prompted the government to seek greater control over the market as a whole and in 1997 banks were formally prohibited from dealing on the exchange market and began to conduct trading on the newly created interbank market (Jingu, 2008). This led to the greater dissolution of the bond market and today the secondary marketplace can be broadly split into three subcategories: the formerly dominant exchange market, which saw trading volumes decline in the post 1997 years; the interbank market, which would become the newly favoured platform given the pre-eminence of commercial banks as the single largest investor set, and the over-the-counter (OTC) market, which typically accounts for a much smaller portion of market activity and serves a primarily institutional investor base (Bai et al, 2013).

Following the establishment of the interbank market, the government resumed the process of liberalising the marketplace, albeit taking a rather more cautious approach than that previously adopted, with numerous changes between 1998 and 2001 aimed at expanding access to the interbank market for alternative financial institutions, while following the introduction of a market maker system in 2001 investors have been allowed to participate in multiple markets and bonds have generally been simultaneously issued across the respective markets (Jingu, 2008). As the Chinese bond market has expanded, issuance volume has markedly increased, which is in turn primarily attributable to a surge in issuance frequency as the Ministry of Finance has over time established a trusted, diversified bond portfolio, operating across a range of maturity profiles with the early focus on 3-, 7-, and 10-year bonds

now supplemented by additional short and longer term offerings. With this expansion of trading volume has come a correspondent increase in the availability of data concerning bond yields, prices etc. and so we have chosen to only include the debt market FSI in our overall financial stress index from 2002. This ensures due concern is paid to debt markets as a potential source of financial stress while also mitigating the risk of arising over concerns regarding the accuracy and validity of bond data in the pre-market maker era.

In our approach to measuring stress levels in the Chinese debt market, we create two separate variables in order to ensure full coverage of the fragmented marketplace. We look to consider both the sovereign debt spread, which indicates the relative degree of liquidity in international markets, and the bond yield spread, which can be viewed as a somewhat reliable forecaster of recessions (Oet et al. 2011). In constructing the debt market Chinese financial stress index (DBCHNFSI), the first variable is defined as the sum of the Chinese 10-year government bond yields (CHN10TB) minus the US government 10- year bond yield (US10TB).

$$Sovereign\ dept\ spread = \mathrm{CHN10TB}_t - \mathrm{US10TB}_t$$

While the second variable is the bond yield spread, which can be used as a forecaster of economic recession within a country as well as a proxy for insecurity within government bond markets. This variable is defined by taking the Chinese long-term bond yield and subtracting the Chinese short-term bond yield.

$$Bond\ yield\ spread = \mathrm{CHN10TB}_t - \mathrm{CHN1TB}_t$$

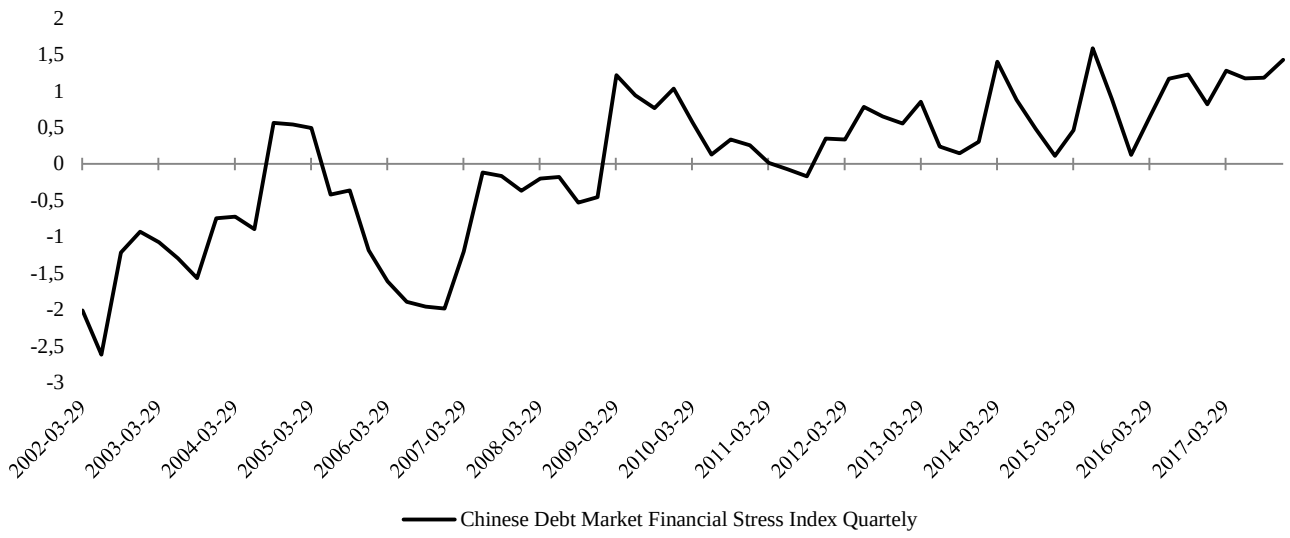
Where $\mathrm{CHN10TB_t}$ denotes the 10-year Chinese government bond yield and $\mathrm{CHN1TB_t}$denotes the 1-year Chinese government bond yield.

Furthermore, to capture the whole effect of the debt market in china there is an necessary to include the corporate debt market. The extent of the corporate debt burden has been an issue of growing prominence both in the media and also in economic literature, with the growth rate of this debt pile rather than the overall amount the prime concern as it far exceeds that witnessed in comparable economies (Elliot et al., 2015). This actually results from deliberate government policy, as the availability of credit expanded rapidly in the wake of the global financial crisis as the state sought to limit its effect by introducing liquidity to the system and ordering banks to lend aggressively. However, the recent deceleration in domestic GDP growth rates has subsequently exacerbated this problem as the government has maintained this credit policy in order to sustain GDP growth. The majority of beneficiaries are

concentrated in the construction, property and energy sectors, which though currently vital to the economy are thought to be in a state of overcapacity, placing the credit at risk as the likelihood of default is substantially greater. The central government does possess a small degree of leeway in managing this burden, as the overwhelming majority is owed by state owned firms to state owned banks while they are also seemingly alert to the credit risk and have taken steps to restructure local and regional government reduce the cost of financing the debt pile. However, this still represents one of the most pertinent sources of financial stress in the modern Chinese fiscal system and so its inclusion will better allow us to judge the extent the stress build-up at any particular point.

Once these variables have been computed, we can combine them with the equal weighting method to create the debt market financial stress index, allowing us to identify periods of high stress across the sector and evaluate probable cause. The resultant sector FSI is shown below.

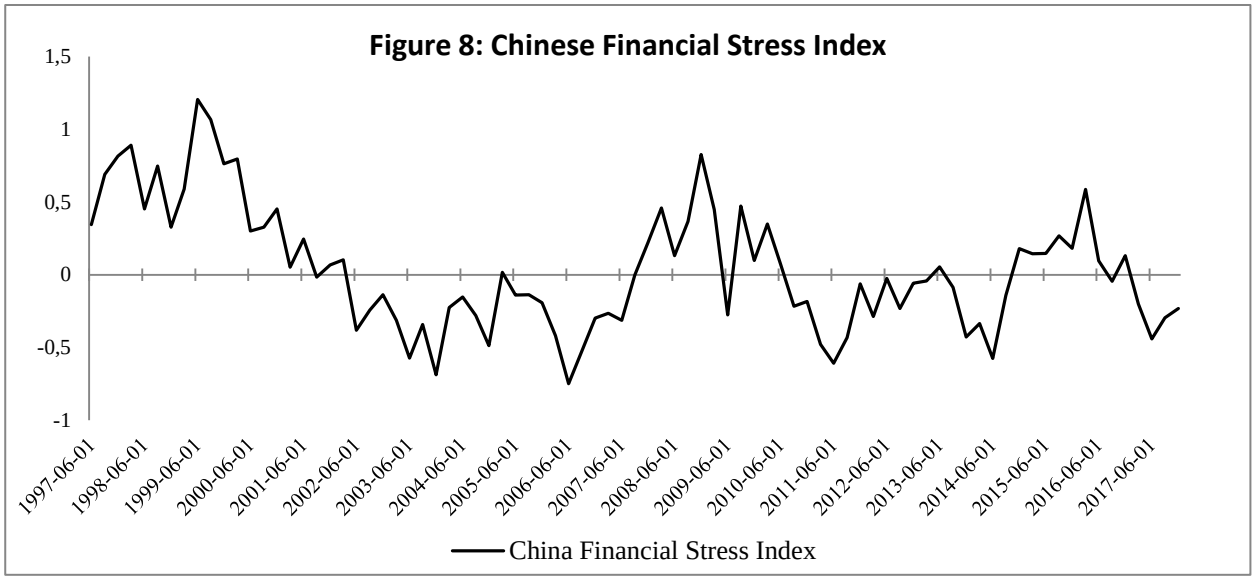
Figure 7: Chinese Debt Market Financial Stress Index Quartely



From the graph, we can easily identify a marked increase in debt market stress over between 2003 and 2005, followed by a relative lull before a spike and subsequent period of sustained agitation in 2009, attributable to contagion effects following the international financial crisis, especially in sovereign bond markets. It is notable how this period demonstrates that debt market stress does not necessarily result from fundamental problems in the domestic economy, as China alone amongst comparable emerging economies saw yields swiftly return to pre-crisis levels (Žigman & Cota, 2011) demonstrating the inherent robustness of the

Chinese economy as it emerged relatively untouched. Further short term spikes can be seen in 2013 and 2015, while the mean stress level also rises throughout this period, a development perhaps attributable to growing concerns over the extent of unreported debt in the shadow banking sector and the corporate debt pile impacting the government's ability to maintain its bond portfolio, especially in light of the widely accepted link between an emerging economy's perceived ability properly service debts and the cost of borrowing (Mendoza & Oviedo, 2011).

3.5 Overall Financial Stress Index



Having completed our analysis of the individual sub-sectors which make up our financial stress index, we can now turn our attention to the combined index. In order to compile this, we first standardised the four sub-sector indexes before assigning each the same weight, following the equal weighting method, with the three sectors used prior to the debt market data becoming available in 2002 assigned 33% weighting and each being assigned a 25% weighting following the inclusion of the debt market. The new overall Chinese financial stress index is then also standardized, meaning the index has a mean of 0 and a standard deviation of 1. By opting to standardize the graph, we aid our ease of interpretation of the index, as now a value of zero equals the historical mean while a value of 1 indicates that the stress is one standard deviation higher than the normal case.

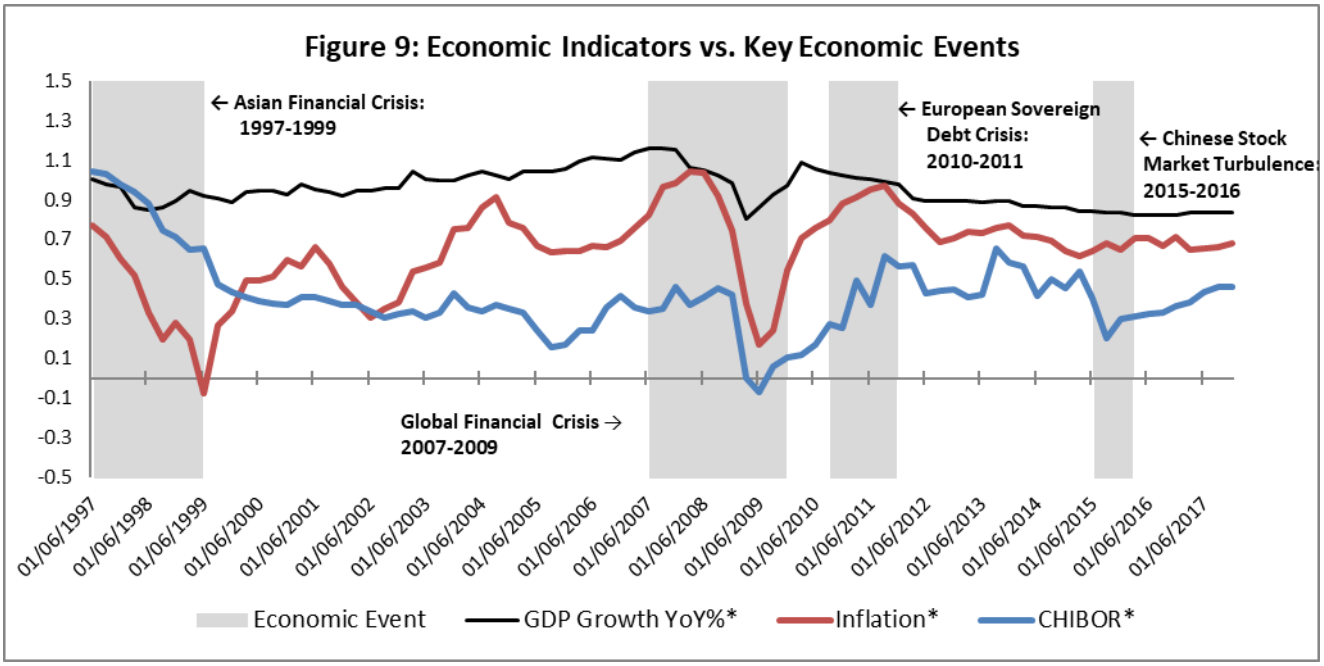
As we can see, this overall stress index again correctly identifies the expected periods of stress, albeit perhaps with even greater accuracy than we achieved in the individual markets. The stress index is visibly higher in conjunction with the Asian financial crisis off 1997 - 1999, the global financial crisis of 2008, the Chinese stock market turbulence of 2015 - 2016

and, to a lesser extent as is consistent with the existing research, the European sovereign debt crisis of 2011. We can observe how in each instance, the degree of stress and the length of time for which the aftereffects of the respective crises are felt, varies dramatically and so this will provide a strong basis as we go on to discuss how the specifics of such effects are conditional on both the resilience of the financial system and the policy response to each event.

4. Empirical Analysis and Results

4.1 Variables and Model Selection

In order to ensure the suitability of our variable selection process with respect to the empirical research, we have considered the examples provided by a broad range of previous literature on the subject of financially related VAR models, (see e.g. Afónso et al., 2011; Balke, 2000; Calza & Sousa, 2005; Atanasova, 2003). Typically, the most frequently occurring of problems within the fiscal VAR model genre are linked to the selection of the variable used to describe the fiscal development and policies. In practice, this means that many VAR models designed to aid the study monetary policy are limited to a single variable model, typically using the central bank interest rate which is sufficient to describe the monetary policy. However, fiscal policy is inherently far trickier to define and thus measure according to a single variable model as this often fails to grasp the broad range of effects encapsulated in such policy. Therefore, in order to grasp the a wider effect of fiscal development and policy, our TVAR follows Afónso et al. (2011) to create a Financial Stress index as an indicator of financial market conditions, and examines this in conjunction with the dependant variable of GDP, Inflation and CHIBOR. After testing the variables for unit roots in levels[4], we transform the GDP, Inflation and CHIBOR to log differences. The output of the transformed data is presented in the Figure 7 below; the grey areas represent an estimation of economic events during the timespan of the studied data.



[4] Not reported for the sake of brevity

The 4x1 vector Y_t in the Threshold VAR model is specified as follows:

$$Y_t = Log\big(GDP_{t,}\big), Log(Inflation_t), Log(CHIBOR_t), CHINAFSI_t$$

Subsequently, the delay parameter given the threshold variable, in this case the CHNFSI, is set to follow the method constructed by Balke (2000). Given the rather small sample size in the thesis, when calculating the TVAR in accordance with Akaike information criteria (AIC), considering lags higher than two in an four variable VAR wouldn't make a lot of sense with only 25 observations in the financial stressful regime. With this in mind, we have decided to set our lag order to two in the TVAR believing that this provides a more appropriate fit to our data.

4.2 Estimated threshold value and non-linearity test

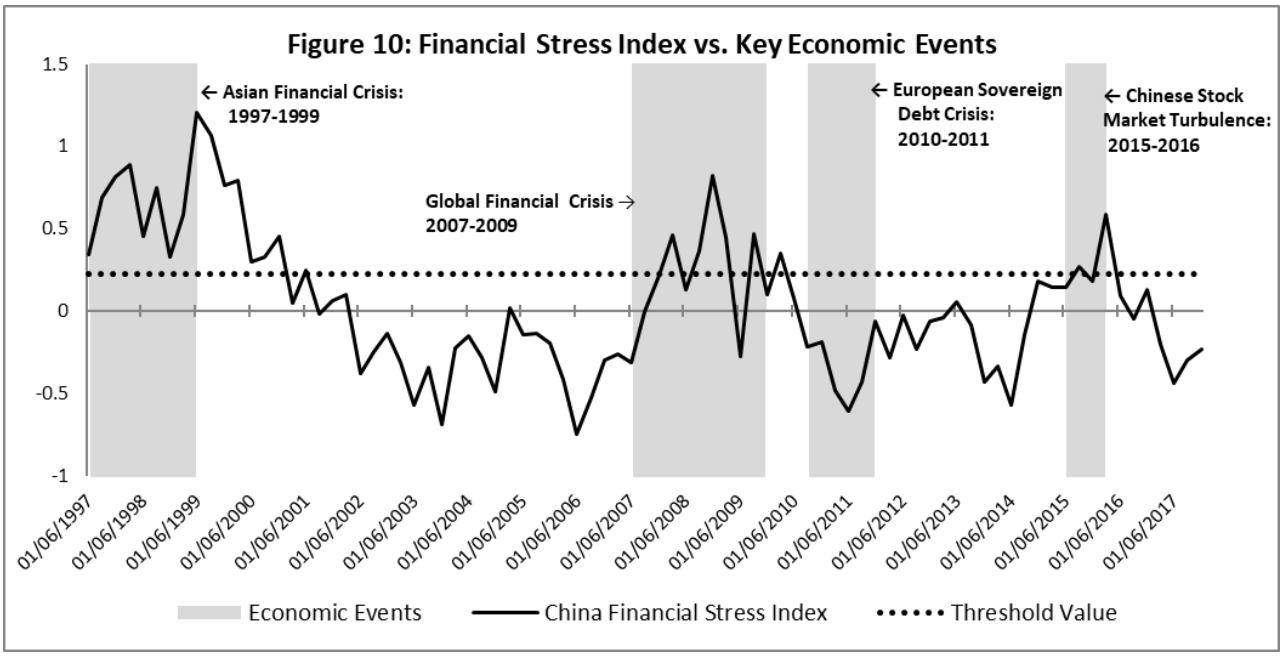
The tables below present the estimated threshold value given to the results of the TVAR model, along with the results of the TVAR model in each regime separately. The results in Table 1 show a p-value of 0,00 for all of the three calculated Wald-statistics, with the p-values calculated in the table using the process outlined by Hansen (1996), These results strongly indicate the suspected presence of nonlinearities, providing support for the use of the two regime threshold VAR model.

Table 1. Threshold Variable	**Estimated Threshold**	**Sup-Wald Statistic**	**Avg-Wald Statistic**	**Exp-Wald Statistic**	**# Observations in High Regime**	**# Observations in Low Regime**
CHNFSI	*y = 0.223384*	*107,69* *(0.000)*	*77,34* *(0.000)*	*50,38* *(0.000)*	*25*	*56*

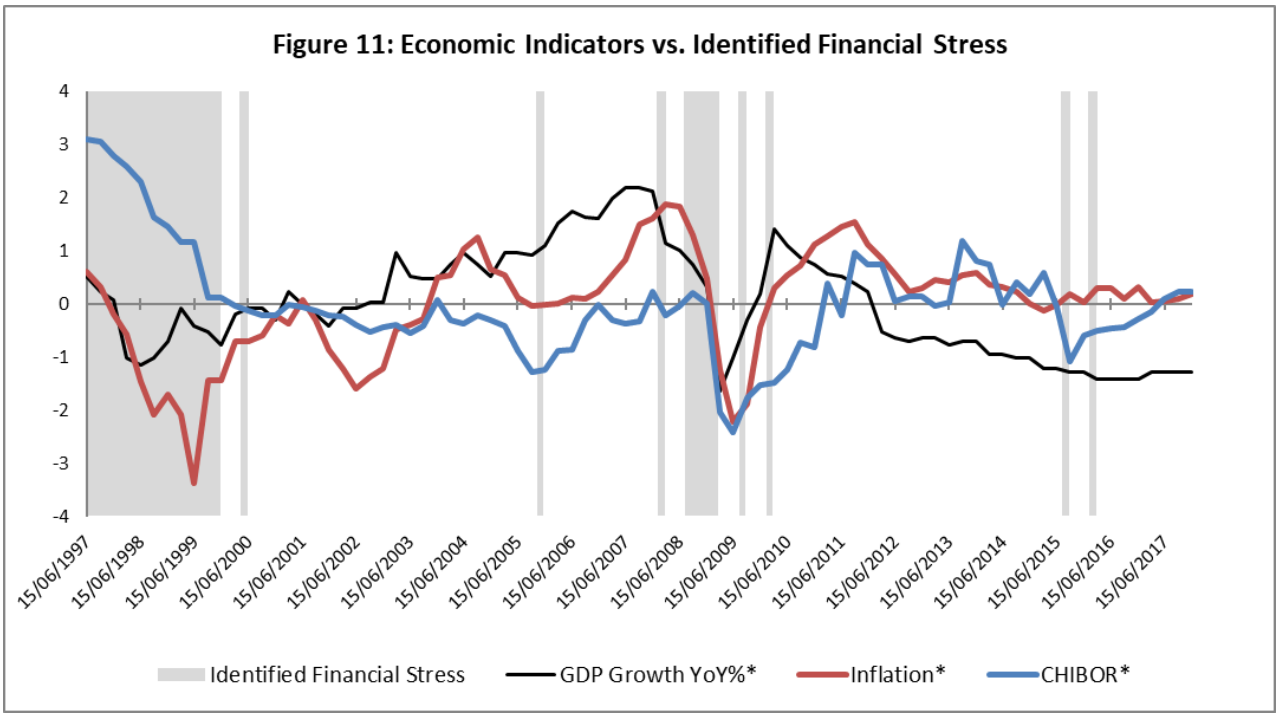
Note: The delay parameter, in accordance with Balke (2000), is set to contain at least 15 % of the total observations.

The estimated threshold value is approximated to 0.223384 for the financial stress indicator, following the procedure outlined in section 2.2. This means that our model estimates China to be in the high stressful regime when the financial stress index is 0.223384 standard deviations higher than the normal case. Thus, the estimation divides the data into two regimes, comprising of 25 observations in the high regime, which is the regime with estimated financially stressful times, and 56 observations in the low regime, which is the regime with the estimated non-financially stressful times.

Figure 10 below shows the plotted Chinese financial stress index along with the estimated threshold value, as well estimated historical key economic factors that may have had an impact on financial stressful times in China as a reference point.



As we can see from the plotted graphs in Figure 10 the estimated threshold value appears to offer a good estimator for historically tracking financially stressful times in relation to key economic indicators. It capture the rise of the Asian financial crisis in 1997-1999, the Global financial crisis in 2007-2009, and the Chinese Stock Market Turbulence in 2015-2016. Meanwhile, although it fails to identify the European sovereign debt crisis as precisely there are a number of contributing factors which may explain such an occurrence. Primarily, it is important to consider the possibility that, as the perceived degree of risk in the European financial system increased, dragging with it that of the majority of developed economies due to the interconnectedness of the global financial system, the relatively insulated Chinese economy could be seen to represent a comparative safe haven. Meanwhile, we can observe an increase in stress in the Chinese financial system concurrent with the extent of the European crisis becoming apparent, suggesting that as fears grew over the possible trade effects of a global slowdown the Chinese system does react albeit with a slight delay.



The * indicates that the variables have been standardized to have zero-mean, for an easier to read graphical representation of the change in the variables.

Figure 11 above displays the identified financial stressful times in relation to change in GDP growth YoY%, Inflation and CHIBOR. This provides a number of interesting insights, for example demonstrating the effect of the Asian financial crisis on GDP growth, resulting in significantly lower levels than the post crisis period. Furthermore, when considering the historical course of the inflation in China we can see that periods where the TVAR estimated the two regimes, the inflation often corresponds to be low in highly stressful times and high in periods of low stress. This follows the research by David and Hakkio (2010), which explains how financial stress typically leads to depressed levels of economic activity and so reduces inflationary pressure. Meanwhile, following a sharp decrease from the pre banking reform 1990's highs, CHIBOR also follows the pattern of inflation, peaking in low stress while declining in during it. This is the opposite of what we would typically expect but upon further examination we can see that in the post reform period CHIBOR is actually fairly consistent outside of the sharp drops in the wake of the global financial crisis and the Chinese stock market turbulence. As discussed, there are varied arguments which could explain the drop correspondent with the global financial crisis but the more localised dip following the stock market turbulence appears to suggest government intervention to introduce more liquidity to the financial system.

4.3 TVAR and VAR Model output

In Table 2 and 3, presented below, we show the model output for both the high stress regime and low stress regime as estimated by the TVAR model (to provide a reference, the results from the linear VAR model are also presented in the appendix, table 3). From these, we can see that the coefficients of the high stress regime and the low stress regime differ noticeably in both sign and size, providing possible indication of the existence of separate economic dynamics during the different financial climates. Furthermore, we can see that the results in the low stress regime differentiate less from the VAR model output, perhaps as a result of the output in the low stress regime containing around 2/3 of the sample size. Interestingly, having examined the results it appears that evidence for the occurrence of prize puzzle is inconclusive as it is only in the high stress regime t-1 and in the linear VAR t-1 that the problem occurs. The Prize puzzle was first identified by Sims (1986) and is a situation in which an increased interest rate (CHIBOR) tends to lead to an increase in inflation, a phenomenon that is general common in fiscally related VAR models, especially when studying monetary policy. The specific puzzle occurs as intuition suggests that an unforeseen constriction in the interest rate would lead to a decline in inflation, whereas in actuality the opposite often is true. One of the explanations for the existence of prize puzzle was suggested by Sims (1992), who proposed that the Federal Reserve methodically reacts by raising the federal funds rate to comply with a higher expectation of the future inflation as a preventive measure to avoid an increase in inflation, This means that the increase in the federal funds rate actually serves to increase the inflation, with the explanation assuming that the Federal Reserve is forward-looking and fails to predict the upcoming inflation.

Table: 2
High Stress Regime **Quarterly Frequency**
TVAR estimates **Included Observations: 25**
Standard errors in ( ) & t-statistics in [ ]

	Δlog(GDP,t)	Δlog(Inflation,t)	Δlog(CHIBOR,t)	CHNFSI
Δlog(GDPt-1)	0.298336	-0.764194	-0.329498	1.013644
	(0.260527)	(0.848357)	(0.546384)	(1.671553)
	[1.145125]	[-0.900792]	[-0.603052]	[0.606408]
Δlog(GDPt-2)	0.674611	1.168897	0.244394	0.767079
	(0.287173)	(0.935125)	(0.602267)	(1.842516)
	[2.349143]	[1.249989]	[0.405789]	[0.416322]
Δlog(Inflation,t-1)	0.057613	0.865947	0.336990	-0.847320
	(0.076475)	(0.249026)	(0.160385)	(0.490666)
	[0.753360]	[3.477337]	[2.101126]	[-1.726876]

	-0.248381	-0.360616	-0.393406	0.157732
Δlog(Inflation,t-2)	(0.078838)	(0.256722)	(0.165342)	(0.311827)
	[-3.150510]	[-1.404696]	[-2.379352]	[0.561422]
	0.032476	0.761714	0.870400	2.124515
Δlog(CHIBOR,t-1)	(0.125140)	(0.407494)	(0.262446)	(0.802902)
	[0.259515]	[1.869267]	[3.316491]	[2.646047]
	-0.014446	-0.951226	0.218166	-1.601248
Δlog(CHIBOR,t-2)	(0.132503)	(0.431471)	(0.277889)	(0.850145)
	[-0.109025]	[-2.204613]	[0.785085]	[-1.883501]
	-0.132509	-0.010073	-0.170994	0.160785
CHNFSI,t-1	(0.039498)	(0.128619)	(0.082837)	(0.253423)
	[-3.354793]	[-0.078319]	[-2.064227]	[0.634452]
	-0.037799	-0.015643	-0.099736	0.124946
CHNFSI,t-2	(0.043100)	(0.140347)	(0.090390)	(0.276531)
	[-0.877005]	[-0.111459]	[-1.103388]	[0.451834]
	0.199791	-0.003942	0.164582	-1.183130
Intercept	(0.133403)	(0.434401)	(0.279776)	(0.855918)
	[1.497656]	[-0.009074]	[0.588263]	[-1.382293]

Table: 3
Low Stress Regime **Quarterly Frequency**
TVAR estimates **Included Observations: 56**
Standard errors in ( ) & t-statistics in [ ]

	Δlog(GDP,t)	**Δlog(Inflation,t)**	**Δlog(CHIBOR,t)**	**CHNFSI**
	0.843798	0.154837	-0.476781	-1.003099
Δlog(GDPt-1)	(0.146662)	(0.426541)	(0.520273)	(1.579360)
	[3.149590]	[0.363005]	[2.382663]	[-0.635130]
	0.089491	-0.157244	0.173101	0.832322
Δlog(GDPt-2)	(0.144863)	(0.421308)	(0.513890)	(1.559983)
	[5.753354]	[-0.373228]	[-0.916404]	[0.533545]
	-0.079137	1.153722	0.301248	-0.590058
Δlog(Inflation,t-1)	(0.048806)	(0.141943)	(0.173135)	(-1.122691)
	[0.617762]	[8.128044]	[0.336844]	[0.982013]
	0.018954	-0.271184	-0.130164	0.729581
Δlog(Inflation,t-2)	(0.049842)	(0.144956)	(0.176809)	(0.536729)
	[-1.621460]	[-1.870807]	[1.739960]	[1.359310]
	-0.038687	-0.010672	0.390270	-0.387995
Δlog(CHIBOR,t-1)	(0.040122)	(0.116688)	(0.142330)	(0.432063)
	[0.380294]	[-0.091455]	[-0.736184]	[-0.898006]
	-0.054815	-0.195374	0.093003	0.187430
Δlog(CHIBOR,t-2)	(0.037352)	(0.108632)	(0.132504)	(0.402233)
	[-0.964233]	[-1.798496]	[2.741996]	[0.465974]
	-0.014873	0.021843	-0.035688	0.518456
CHNFSI,t-1	(0.013099)	(0.038096)	(0.046467)	(0.141057)

	[-1.467518]	[0.573383]	[0.701892]	[3.675515]
CHNFSI,t-2	-0.025624	-0.064248	-0.063611	0.040995
	(0.014335)	(0.041690)	(0.050851)	(0.154365)
	[-1.135446]	[-1.541089]	[-0.768030]	[0.265574]
Intercept	0.133146	0.161152	0.357315	0.077254
	(0.042274)	(0.122947)	(0.149964)	(0.455237)
	[-1.787548]	[1.310746]	[-1.250929]	[0.169700]

4.4 Nonlinear Impulse-response Analysis

As we have rejected the linear VAR model and are thus constructing the TVAR model, we can now proceed to look at how the economic dynamics interact in each regime separately. When analysing the model output, we use a recursive order of the TVAR model as follows:

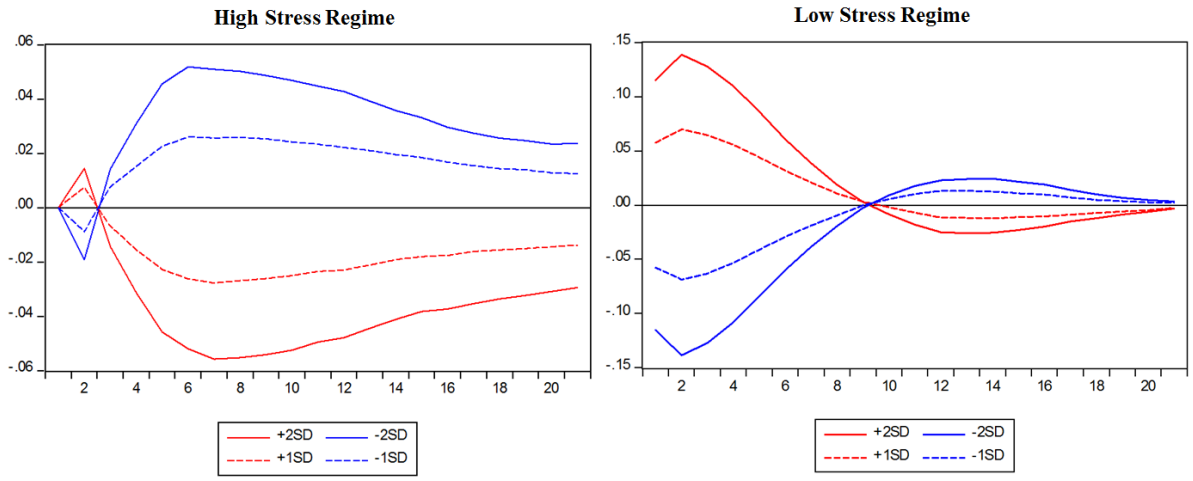
$$\Delta\log(GDP_t) \rightarrow \Delta\log(Inflation_t) \rightarrow \Delta\log(CHIBOR_T) \rightarrow CHINAFSI_T$$

It is important to bear in mind the manner in which the explicit ordering of the variable in the recursive TVAR means the later variables will respond simultaneously when there is a shock to GDP growth, whereas GDP growth only responds to a shock to one of the other variables in the recursive system with a lag of one or two quarters. As such, CHIBOR responds simultaneously to a shock in GDP growth and inflation. However, inflation and GDP growth respond to changes in CHIBOR after one or two quarters respectively. This also means that the response from shocks to the CHNFSI are merely transferred towards the other variables after one or two quarters while the accordant response of shocks to any other variables will have a simultaneous effect on the CHNFSI.

4.4.1 Response of GDP & Policy Explanation

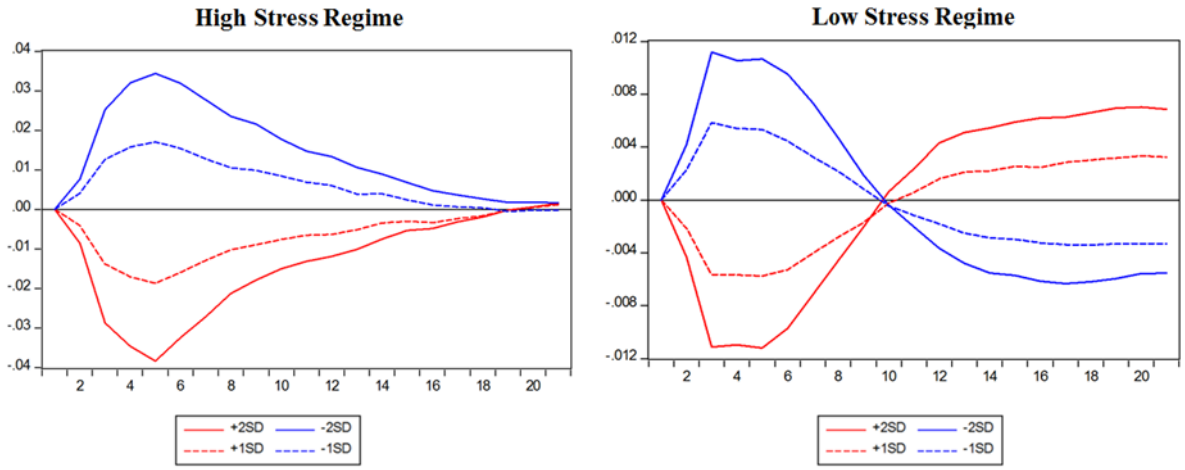
Figures 12 to 14 shows the impulse responses of GDP growth to shocks in the other economic endogenous variables in the TVAR model. In the graphs, the red lines show the effect on the response variable of a positive impact from the shock variable whereas the blue lines show the effect of a negative shock.

Figure 12:
Response Variable: Δlog(GDP)
Shock Variable: Δlog(Inflation)



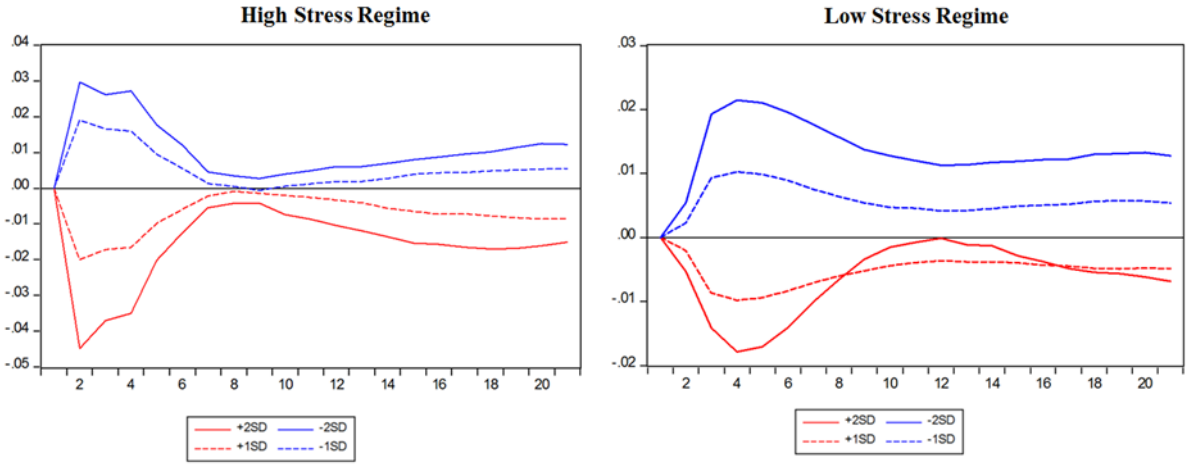
As shown in Figure 12, a positive shock to inflation in the high regime case tends to induce positive short-term movement in GDP growth, but the effect of the impact quickly shifts and becomes negative, with the long-run impact seemingly harmful to GDP Growth. In the low stress regime this effect is replicated, as a positive shock to inflation has a short-term positive impact on the GDP growth but here to the effect reverts to produce a negative impact on the GDP Growth as more time elapses. However, under both regimes GDP Growth appears to be recovering as time goes on, suggesting that perhaps inflationary expectations adjust to mitigate the impact, roughly echoing the theories of Friedman examined earlier (Gordon, 2018).

Figure 13:
Response Variable: Δlog(GDP)
Shock Variable: Δlog(CHIBOR)



In Figure 13, GDP growth reacts negatively in the short and medium term to a positive shock in CHIBOR in the high stress regime, and while the long-run effect actually turns positive over circa 20 periods the mean impact is overwhelming negative. Meanwhile, in the low stress regime a short run negative response to a positive CHIBOR shock is followed by a strong positive reaction. We can perhaps interpret this as a signal that during financially stressful times the economy is more vulnerable to monetary policy changes, whilst any positive changes in interest rates during periods of low stress are typically the result of government policy intended to reduce inflation and so prevent the economy from overheating, aiding GDP growth in the long-run.

Figure 14:
Response Variable: Δlog(GDP)
Shock Variable: China FSI



In figure 14, as we would expect a positive shock to the overall financial stress index produces a negative impact on GDP growth during both regimes in the short-run, and while growth recovers in the medium term it fails to sustain these levels over time. Furthermore, the effect of the shock is notably greater if it occurs during a period of high stress when compared to the low stress regime, mirroring the findings of Afónso et al. (2011) and illustrating how a stressful financial environment can act as a multiplier to the effects of a fiscal shock. Additionally, a negative shock during high stress regime appears to have far more dramatic impact than a negative shock, thus demonstrating the occurrence of nonlinearities within the regime.

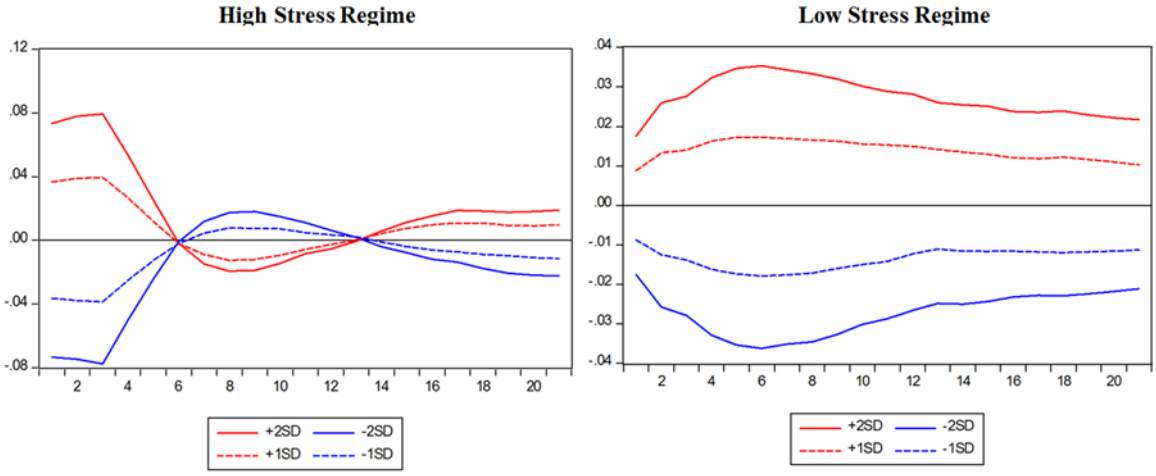
Overall, we can clearly see that the responses of GDP growth to shocks are far more volatile in the high stress regime, with growth either permanently depressed or taking far longer to recover in comparison to the low stress regime. From this we can infer that, as we would expect, the economy is more vulnerable to shocks during periods of high financial stress and

so, in order to maintain the consistently high GDP growth figures exhibited over the previous few decades, it is important that monetary policy seeks to minimise the span of these stressful periods.

4.4.2 Response of Inflation & Policy Explanation

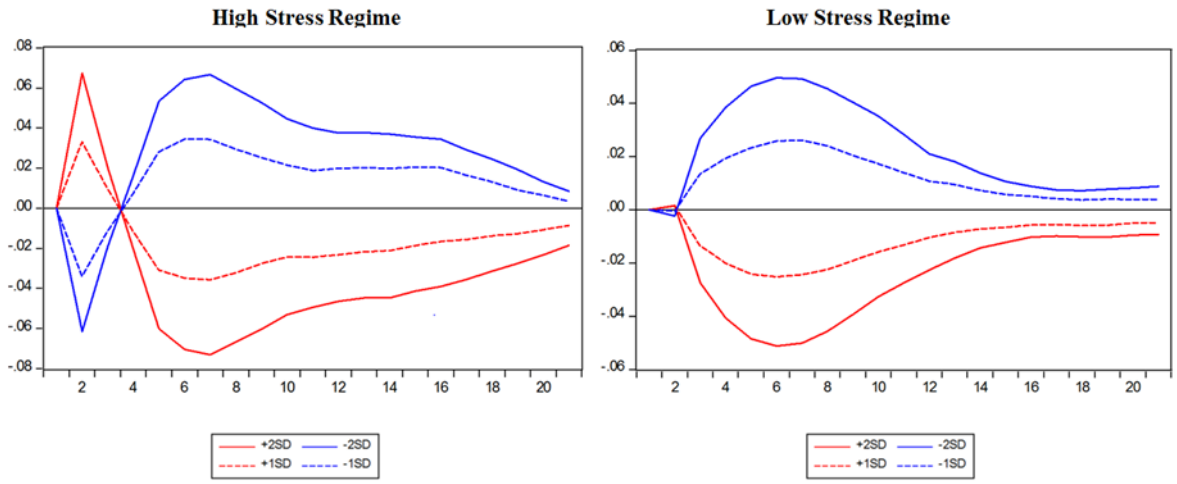
Figures 15 to 17 show the impulse responses of Inflation to shocks in the other economic endogenous variables in the TVAR model.

Figure 15:
Response Variable: Δlog(Inflation)
Shock Variable: Δlog(GDP)



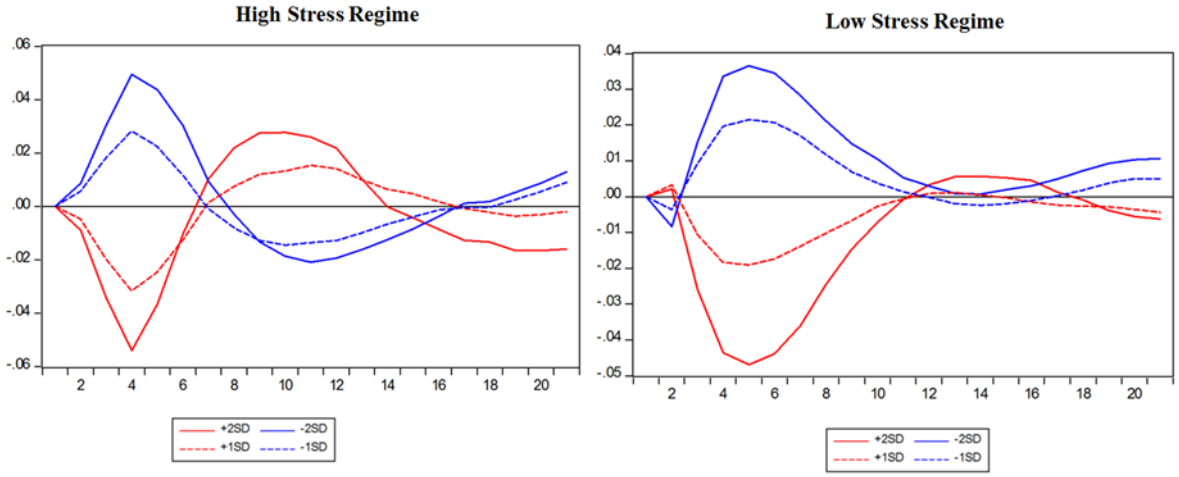
As seen in Figure 15, there is a significant difference between the responses of inflation to a shock in GDP growth dependant on the economic conditions in which the shock occurs. In periods of high stress, a positive shock to GDP growth causes inflation to initially increase, followed by a decrease in the mid-term before inflation recovers to settle at a level slightly higher than before. The initial increase and the long-term settled value falling above pre-shock levels both follow the pattern we would expect, however the mid-term decrease represents a slight abnormality which standard theory fails to account for. In the low stress regime, inflation responds positively to an increase in GDP growth at a more stable level, as the standard theory would suggest. When an economy is healthy, we would normally expect an increase in GDP to lead to an increase in real wages and low unemployment, thus leading to a higher purchasing power and a higher demand for goods. This in turn leads to an increase in prices, followed by a rise in inflation.

Figure 16:
Response Variable: Δlog(Inflation)
Shock Variable: Δlog(CHIBOR)



In Figure 16, we can see that, in the low stress regime; the average effect of a positive shock to CHIBOR has a negative effect on inflation, a finding which fits the standard economic theory as generally when interest rates appreciate the correspondent reduction in liquidity means there is a drop in the available capital as the cost of borrowing increases and consequently, a decrease in inflation. These findings are replicated in the high stress regime over the long-term, albeit with the proviso in the short term we see a positive spike in inflation following a positive shock in CHIBOR. This is possibly explained by the abnormalities we discussed in the compilation of the CHIBOR data, which saw the index experience sharp drops in financially stressful periods before undergoing a swift recovery. Previously, we theorised that the drop may result from state interference in the market and so the recovery is simply the resumption of normal market conditions. If correct, this would the situation we see parlayed in the data as when CHIBOR experiences such a recovery in periods of stress, inflation typically recovers simultaneously as economic activity ramps up. Therefore such a finding may not identify a natural effect but rather represent the power of state intervention to distort regular market functions, at least in the short-run.

Figure 17:
Response Variable: Δlog(Inflation)
Shock Variable: China FSI



Turning now to Figure 17, the graphs show that a positive shock to the greater financial stress index leads to an initial decrease in inflation before it increase in the medium term and eventually stabilises at a slight reduction to the initial level, a pattern replicated in both regimes although featuring far more dramatic swings in during high stress conditions, once again verifying the existence of asymmetries between the two regimes. This behaviour appears consistent with our theory as, following a positive shock the inflation would initially decrease as increased stress leads to a reduction in economic activity. Latterly, inflation will increase as throughout the timespan we are investigating each financial shock has been swiftly followed by a period of recovery, where an increase in GDP growth is closely followed by an increase in inflation, while typically inflation declines over time as the economy matures, as again displayed in the data. As such, we can conclude that positive shocks in financial stress, particularly during a high stress regime, leads to multiple degrees of volatility in inflation but ultimately has a dampening effect in the long-term.

In terms of our overall impressions, we can see that in, the high stress regime, inflation typically displays a far greater sensitivity to shocks in the short-term although the disparities between the regime dependant portion of the shock's effect are negligible over time. Meanwhile, we can see that in terms of the persistence of the effects of shocks, inflation is typically most responsive to a shock in GDP growth with the shock responses in the case of the other variables appearing to trend towards the pre-shock levels over time.

4.4.3 Response of CHIBOR & Policy Explanation

Figures 18 to 20 show the impulse responses of CHIBOR to shocks in the other economic endogenous variables in the TVAR model.

Figure 18:
Response Variable: Δlog(CHIBOR)
Shock Variable: Δlog(GDP)

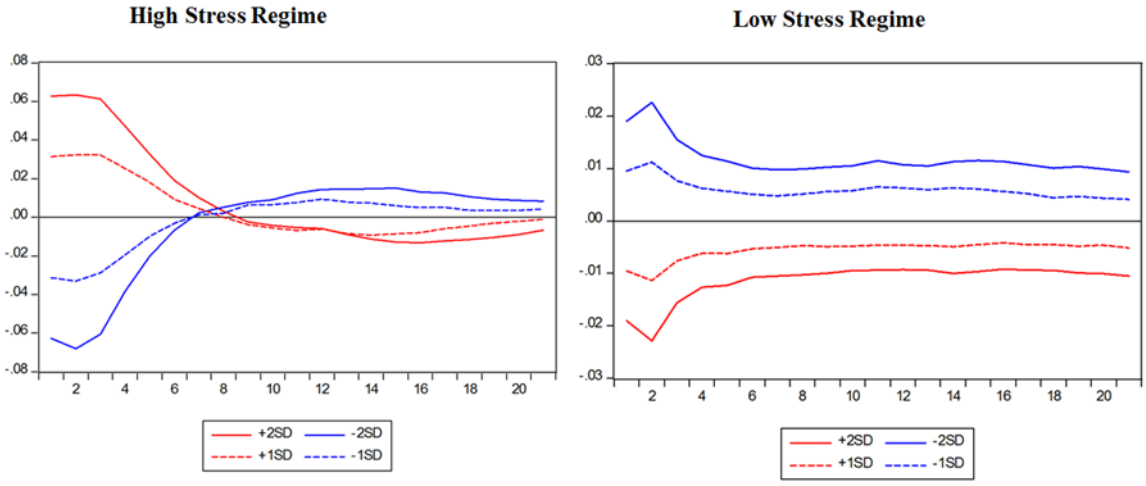
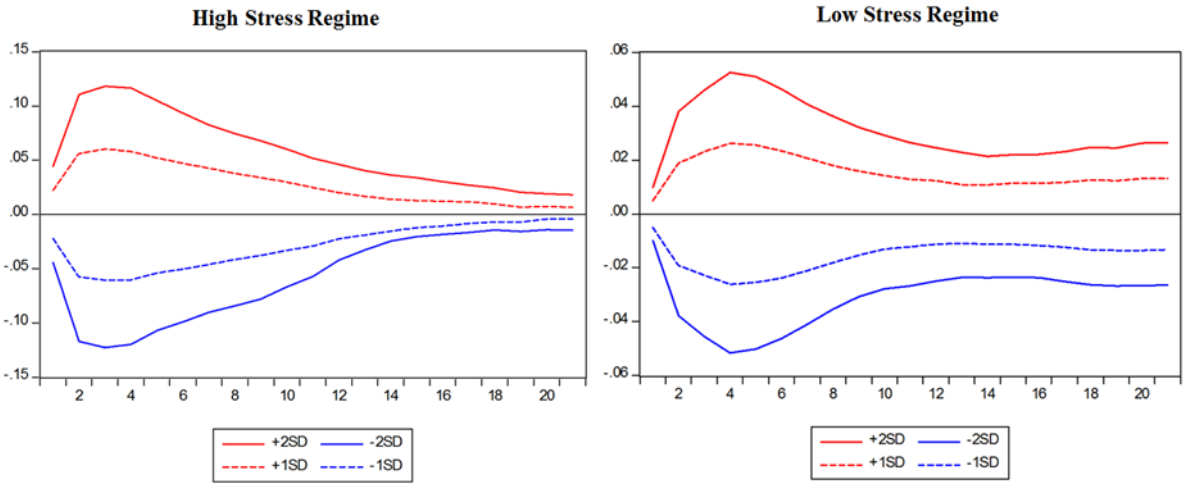


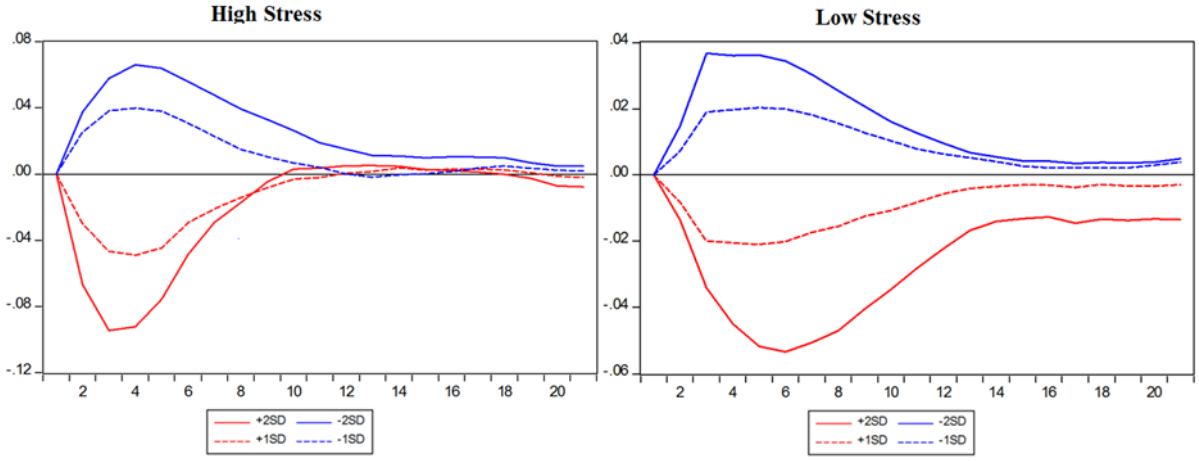
Figure 18 displays the reaction of CHIBOR to a shock in GDP growth under both regimes. Once again we can see the asymmetries between both regimes as, in the high stress regime, a positive shock to GDP growth increases the CHIBOR short-term before it eventually declines while in the low stress regime a positive shock initially lowers the interest rates and while they do recover they settle at a level slightly lower than previously witnessed. In the high stress regime, we would perhaps expect a slight lag before interests rates decline as despite GDP growth if the economy is under financial stress then it is understandable that there may be an element of institutional scepticism as the market participants could still judge the environment to be high risk until the growth trend is better established. In the low stress regime, CHIBOR follows the pattern we would expect from the theory, decreasing in the short term as the perceived risk decreases before displaying a slight long term increase consistent with the typical behaviour of interest rates following an increase in the growth rate.

Figure 19:
Response Variable: Δlog(CHIBOR)
Shock Variable: Δlog(Inflation)



In Figure 19, we can see that in both regimes the pattern are similar, and a positive shock in inflation elicits a positive response in CHIBOR, which follows the standard economic theory. As previously mentioned, the standard monetary policy will be to adjust to increasing/decreasing inflation through lower/higher interest rates respectively and here the market defined rates such as CHIBOR typically follow.

Figure 20:
Response Variable: Δlog(CHIBOR)
Shock Variable: CHINAFSI



In figure 20, we can see how CHIBOR responds to a shock in financial stress in both stress regimes. Once again we can acknowledge the existence of asymmetries between the regimes - as the magnitude of the effect in the high stress regime is almost double that of the low stress - as well as nonlinearities between a positive and negative shock in both regimes individually. During both regimes an increase in financial stress will lower the CHIBOR, a result which runs contrary to standard economic theory but which as outlined we hypothesis may appear

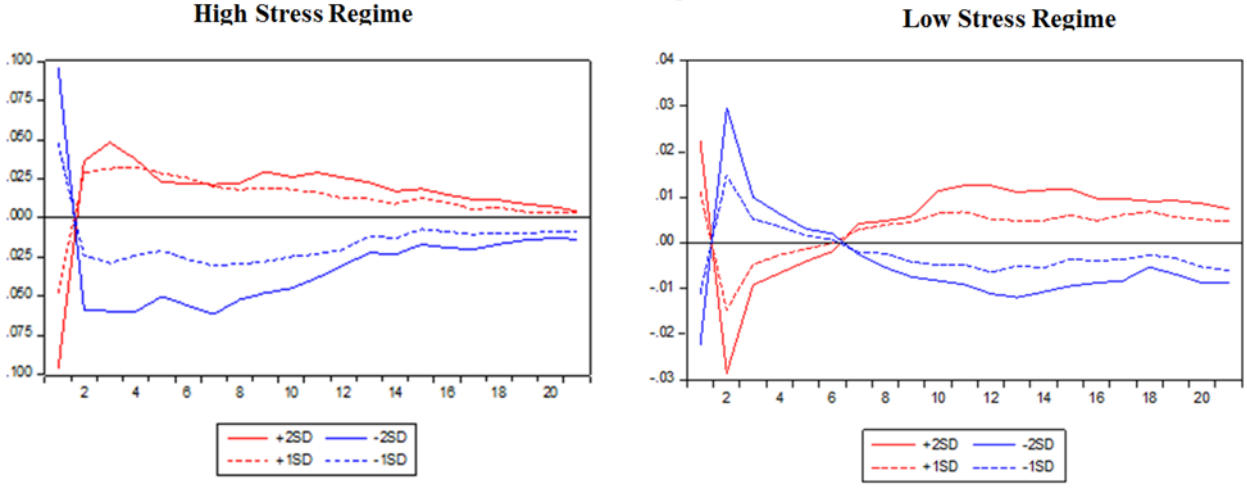
either from state interference in the interbank market or due to the fact that fiscal stress as we identify it tends to correspond to periods of trauma in international markets and so the perceived degree of risk of lending in China decreases even as the financial stress increases.

When looking to identify common features amongst the reactions, we can clearly see that, as with the variables previously considered, CHIBOR exhibits far more volatile reactions to shocks which occur when in the high-stress regime. Given the common acceptance of the importance of consistency and stability in the setting of interest rates, this volatility would appear to result in negative consequences for the greater economy and so provides further evidence as to the importance of evading unnecessary stress where possible.

4.4.3 Response of CHNFSI & Policy Explanation

Figures 21 to 23 show the impulse responses of CHNFSI, the overall Chinese Financial Stress Index, to shocks in the other economic endogenous variables in the TVAR model.

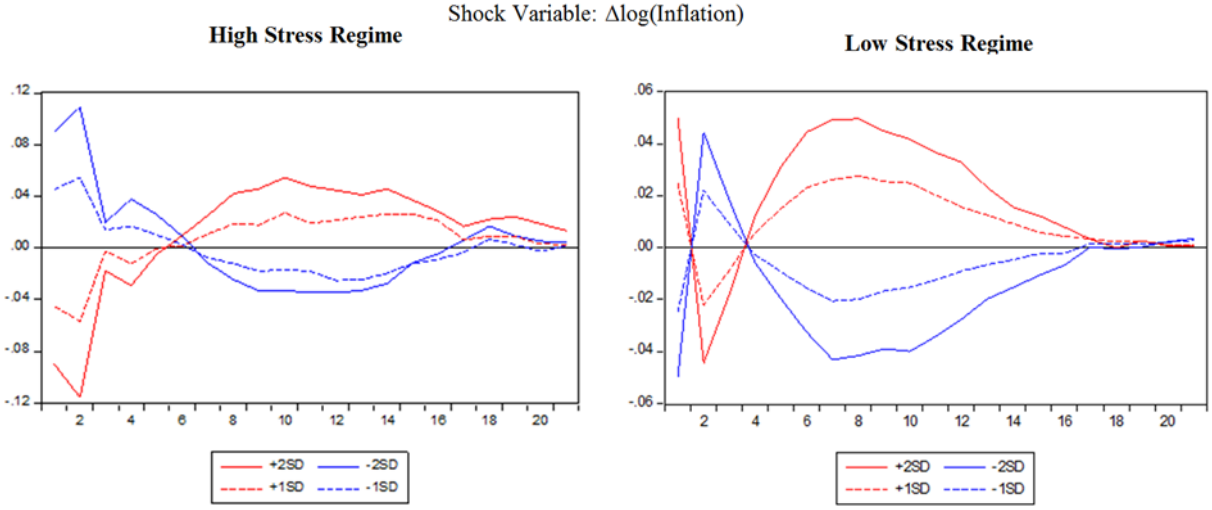
Figure 21:
Response Variable: CHINAFSI
Shock Variable: Δlog(GDP)



As seen in Figure 21, following a positive shock in GDP growth, the response of financial stress in the high stress regime is an initial decrease in stress levels which is in turn followed by a sharp uptick with stress levels soon settling at a level slightly higher than previously, although they do appear to eventually trend towards the mid-line, indicating a long-term return to pre-shock levels. This means that during financially stressful periods an increase in GDP growth further stimulates the financial stress, which goes in line with the findings of Chiu & Hacioglu (2016). When examining the results in the low stress regime, the initial response to an increase in GDP growth is a correspondent increase, followed by a sharp decrease to a lever lower than previously experienced before the stress index recovers and

settles at a level slightly higher than before. This could be interpreted as evidence of the cyclical nature of financial stress, with an increase in GDP growth initially associated with higher stress levels as positive GDP shocks typically occur as part of a greater recovery from a economic contraction. This leads into a more stable economy and therefore less financial stress in the mid-term, but over time the longer the GDP growth continues the more likely the next period of stress becomes.

Figure 22:
Response Variable: CHINAFSI
Shock Variable: Δlog(Inflation)



Represented in Figure 22, the responses of the stress index in China to shocks to inflation. In both regimes there is asymmetry within the regimes, leading us to, once again, acknowledge the presence of nonlinearities. During the period of high stress our results show an increase in inflation has a negative impact on financial stress, meaning higher inflation leads to less financial stress in the short term before stress increases above the previous level in the mid to long-term. Meanwhile, in the low stress regime we do see a short term rise in stress followed by a mid-term reduction and finally a long-term rise. This slight abnormality may be explained by the fact that strong positive swings in inflation are typically correlated with economic recovery in our data, and as such stress will decrease synchronically even though the long-term effect of such a shock will lead to an overall raise in stress levels.

Figure 23:
Response Variable: CHINAFSI
Shock Variable: Δlog (CHIBOR)

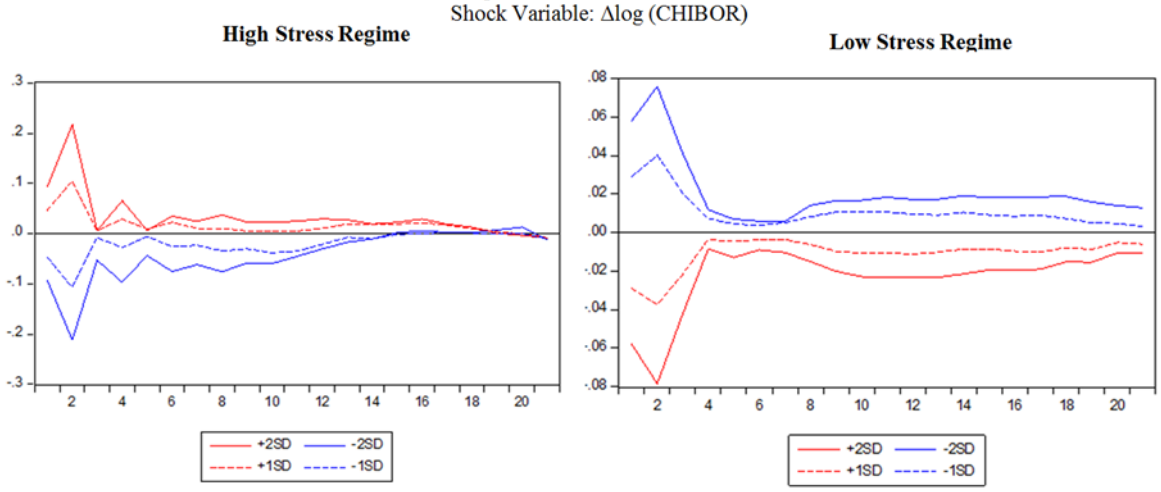


Figure 23 represent the response of the financial stress index to a shock in CHIBOR, and we can see that in the high stress regime an increase in CHIBOR will further stimulate the financial stress in the near-term. This follows the expected theory as often recessions or financially stressful times force interest rates downwards as a monetary policy measure to provide stimulation for the economy. As discussed, CHIBOR is notionally subject to market pricing but even without tangible evidence of state interference we can assume that given the centralised control of, for example, the lending and deposit rates (Porter & Xu, 2009) there will be downward pressure due to policy in similar markets in the result of financial stress. During the low stress regime we see that an increase in CHIBOR has a negative impact in financial stress, a result which suggests that a rise in interest rates during non-stressful periods is perhaps due to government policy designed to curb inflation.

When considered collectively, we can see that the reactions of the stress index are far more volatile during high stress regimes, demonstrating the manner in which stress can compound as the existence of a prior build-up of fiscal stress amplifies the volume of additional stress created by a shock. Meanwhile, it is interesting to note that none of the shock variables considered appears to have produced a paradigm shift in the stress index, as in each case it appears to trend towards the pre-shock level in the long-run. This could be interpreted as further evidence of the manner in which extreme periods of stress result from a combination of shocks across separate markets, further emphasising the importance of ensuring a base understanding of the pattern by which stress reverberates through the economy to ensure such shocks can be properly contained.

5. Conclusion

Having conducted our analysis into the broad effects of financial stress in the Chinese economy, there are a number of interesting points which merit underlining. Firstly, we have identified numerous occasions in which the standard economic theory fails to explain the dynamics of a specific situation, with some of the shock responses apparently counterintuitive when considered in a vacuum. This accentuates the importance of developing a holistic understanding of both the specificities of the Chinese economy and the potential effects of transcendent fiscal developments from the interconnected global economy, providing further evidence that despite the increasing insulation provided by sheer scale of China's domestic market, it is still vulnerable to de-stabilizing shifts in international trade flows. This leads into the second crucial point, which is despite the apparent consistency of China's growth in GDP, our model clearly demonstrates the prevalence of cyclical financial stress within the economy, often arising from exogenous shocks but equally capable of resulting from endogenous sources, arguably including the stock market turbulence of 2015. This suggests that rather than the Chinese political model offering a framework to create a post business-cycle economic environment – such as that we have equally seen to be falsely heralded at times in developed economies – the economy does experience recurring peaks and troughs in stress levels which the shock impulses show result in depressed GDP growth. At this point in time, the sheer strength of this GDP growth trend ensures that these negative shocks fail to translate to recessionary periods, but as China continues its development, we can expect it to exhaust the remaining sources of 'catch-up' growth available and, if the middle income trap is successfully avoided, transition into complete a developed economic model complete with the resultant lower GDP growth common in such economies given the inherent complexity in creating 'frontier' growth. This weakening of the growth trend will mean that in future periods of financial stress are increasingly likely to result economic slumps, dictating the need for a greater understanding of the dynamics of such cyclical stress in order to successfully guide the economy through potential downturns. Currently, with the need to finance the corporate debt burden as well as the decline in foreign reserves reducing the defensive buffer available to policymakers, the situation is extremely precarious and any negative shock could result in severe economic trauma. This situation is exacerbated by the suggestion uncovered in the shock impulse analysis that the central party often relies on CHIBOR to introduce liquidity to the economy in stressful periods, as despite the prior effectiveness of this policy, if future stress arises from the debt market then it is unlikely to be near as effective given the 54

implications of such on the trust within the fiscal system. However, the government is clearly aware of the hazards before it and is taking steps to alleviate potential sources of such stress through, for example, increasing transparency and enacting structural reform in the banking sector, as well as beginning to tackle the question of soft loans as it attempts to improve the shock resilience of the domestic economy. This is timely, as the cyclical nature of stress ensures that the effectiveness of such actions will be tested in due course and when this occurs it is vital, especially given the increasing importance and prominence of China in the global economy, that enough is done now to avoid amplifying a potential crisis to come. With this in mind, we would recommend that updated research is conducted into identifying potential blockages in the fiscal system leading to the build-up of stress in the manner of Sun & Huang (2013), whilst also emphasizing the importance of developing a greater understanding of the mechanisms guiding China's economic transition to a developed state, as fully comprehending the exact nature of this is vital in assessing the future trend of the GDP growth.

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7. Appendix

Table 1 Appendix - Variables and Data sources

Markets	Variables	Data Source	Frequency	Period
Banking Sector	Interbank Lending Rate	Datastream*	Monthly	June 1997 - Dec 2017
	Government Bond Yield	CEIC**	Monthly	June 1997 - Dec 2017
	Non-Performing Loans	Various***	Yearly, Monthly	1997-2003, Jan 2004 - Dec 2017
	Total Loans to Total Deposits Ratio	CEIC	Monthly	June 1997 - Dec 2017
Stock Market	Shanghai Stock Market Index	Datastream	Monthly	June 1997 - Dec 2017
Foreign Exchange Market	Real Exchange Rate	CEIC	Monthly	June 1997 - Dec 2017
	Foreign Reserve	CEIC	Monthly	June 1997 - Dec 2017
Debt Market	10 Year Government Bond Yield China	Blomberg****	Monthly	Jan 2002 - Dec 2017
	10 Year Government Bond Yield US	CEIC	Monthly	Jan 2002 - Dec 2017
	1 Year Government Bond Yield	Blomberg	Monthly	Jan 2002 - Dec 2017
	Corporate Debt Market	CEIC	Monthly	Jan 2002 - Dec 2017
Macroeconomic Variables	GDP Growth	Datastream	Quartely	June 1997 - Dec 2017
	Inflation	Datastream	Monthly	June 1997 - Dec 2017
	CHIBOR	Datastream	Monthly	June 1997 - Dec 2017

*Thomson Reuters Datastream

**CEIC Data Company Ltd

***(Xiao, 2005), (Shi, 2004), (Bihong, 2007), CEIC Data Company Ltd

****Bloomberg Professional

Table 2 Appendix - Summary Descriptions of Financial Stress Indexes

Authors	Banking System	Equity (Stock) Market	Foreign Exchange Market	Debt Market	Weights
Balakrishna n et al. (2009)	Banking system Beta: $B_{it} = COV(r_{it}^b, r_{it}^b, r_{it}^m)/\sigma_{i,m}^2$	1. Stock Market Returns: Calculated by taking the yearly change in their stock index multiplied by -1. 2. Stock market volatility: Using an GARCH(1,1) with 12 lags on monthly basis monthly	$EMPI = \frac{\Delta e_t - \mu_{\Delta e_t}}{\sigma_{\Delta e_t}} - \frac{\Delta RES_t - \mu_{\Delta RES_t}}{\sigma_{\Delta RES_t}}$	Sovereign Debt Spread is calculated by taking the 1 year Bond Yield - the 10 year US treasury yield	Variance-equal weighting
Shahnazarian, H., & Bjellerup, M. (2015)	TED Spread(3-month treasury bill -3-month STIBOR)	Volatility measured by taking the standard deviation for stock index over the last 30 days.	The Volatility of the SEK exchange rate in relation to the Euro, measured by the standard deviation for the past 30 days.	The mortgage spread*	Equal Weighting
Lai and Lu (2010) (Chinese)	1. Measured by Using the term spread* 2. The Banking's systems risky spread*	Using CMAX for voltility of the stock market and GARCH(1,1)*	EMPI the same way as (Balakrishnan et al. (2009)	Excluding	Variance-equal weighting
Cardarelli et al. (2009)	1. Bank Sector beta (as Balakrishnan et al. (2009)) 2. The TED spread (3-Month Treasury bill – 3-month LIBOR) 3. Inverted term spread*	1. The Corporate Spread* 2. The Stock Declines* 3. GARCH(1,1), time-varying stock volatility*	GARCH(1,1), Using time varying real effective exchange volatility*	Excluding	Equal Weighting
Oet et al. (2011)	1. The bank bond spread* 2. Interbank liquidity spread* 3. Interbank spread of cost of borrowing* 4. Financial Beta*	Measured by look at Stock market crashes, where x is the overall Stock index: $x_t/MAX[x \in x_{t-j}, j = 0$	Measured by using weighted dollar crash, where x is the trade weighted US-dollar exchange index: $x_t/MAX[x \in x_{t-j}, j = 0$	1. Bond Yield spread* 2. 90 Day commercial paper treasure bill spread* 3. Governed Interest Spread* 4. Liquidity spread* 5. Treasury yield curve spread*	CDFs: $\int_{-\infty}^{x_j} f(x_{jt})dx_{jt} CDF(Z_t) = \frac{RANK(Z_t)}{No.\ of\ daily\ Obs.}$

*See the source for more information

Appendix Table 3: Linear VAR Quarterly

Included observations: 81 after adjustments

Standard errors in ( ) & t-statistics in [ ]

	Δlog(GDP,t)	Δlog(Inflation,t)	Δlog(CHIBOR,t)	CHNFSI
Δlog(GDPt-1)	0.717298	-0.094187	0.221615	2.221731
	(0.11777)	(0.33547)	(0.32446)	(0.98940)
	[6.09078]	[-0.28076]	[0.68302]	[2.24553]
Δlog(GDPt-2)	0.222887	0.165816	-0.293149	-1.957281
	(0.11683)	(0.33281)	(0.32189)	(0.98155)
	[1.90773]	[0.49824]	[-0.91072]	[-1.99408]
Δlog(Inflation,t-1)	0.009164	1.068599	0.219749	-0.508043
	(0.03853)	(0.10976)	(0.10616)	(0.32372)
	[0.23783]	[9.73572]	[2.06998]	[-1.56940]
Δlog(Inflation,t-2)	-0.110406	-0.329249	-0.184214	0.521969
	(0.03933)	(0.11202)	(0.10835)	(0.33039)
	[-2.80744]	[-2.93912]	[-1.70021]	[1.57986]
Δlog(CHIBOR,t-1)	-0.025401	0.145287	0.688877	0.492039
	(0.04246)	(0.12096)	(0.11700)	(0.35676)
	[-0.59817]	[1.20108]	[5.88807]	[1.37919]
Δlog(CHIBOR,t-2)	-0.020329	-0.278698	0.199875	-0.082101
	(0.04315)	(0.12293)	(0.11889)	(0.36254)
	[-0.47110]	[-2.26722]	[1.68114]	[-0.22646]
CHNFSI,t-1	-0.037269	0.015437	-0.044813	0.535939
	(0.01325)	(0.03775)	(0.03652)	(0.11135)
	[-2.81198]	[0.40888]	[-1.22721]	[4.81316]
CHNFSI,t-2	0.005534	-0.065574	-0.005986	0.253788
	(0.01347)	(0.03836)	(0.03710)	(0.11314)
	[0.41090]	[-1.70930]	[-0.16132]	[2.24305]
Intercept	0.139785	0.156453	0.085147	-0.430935
	(0.04246)	(0.12095)	(0.11698)	(0.35671)
	[3.29225]	[1.29357]	[0.72788]	[-1.20809]