Essays on Inflation, Output and Monetary Policy in Post Reform China

Paul G. Egan

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Thesis Supervisor: Dr. Anthony Leddin

Department of Economics, Kemmy Business School,
University of Limerick

A Thesis submitted in fulfilment of the requirement for a Degree of Doctor of Philosophy in Economics
China’s economic achievement over the past three decades has been remarkable. It has managed to maintain a sustained period of unprecedented growth since its reform and “opening-up” policies of 1978. As China is now as important an engine for growth in the world economy as the United States, understanding fragilities in Chinese macroeconomic structures is more important than ever before. Due to its increased integration into the global economy, interpreting the dynamics of Chinese inflation, output growth and monetary policy is vital, both in theory and in practice, especially for central banks in the conduct of economic policy. This thesis will attempt to provide an analysis of the dynamics of inflation, output and monetary policy in the Chinese economy through augmented versions of a Phillips curve, an Investment Savings (IS) curve and a monetary policy “Taylor type” rule. The thesis is structured as follows. Chapter 1 gives an introduction to the thesis, establishes the motivation for this research, outlines the methodology as well as the central research question, and discusses the structure of the thesis. Chapter 2 provides a general overview of the Chinese economy while discussing some of the main macroeconomic indicators. Chapter 3 examines the inflation process in China by estimating variations of the Phillips curve. Chapter 4 investigates the effectiveness of the monetary policy transmission channel in China by estimating an IS curve equation using a monetary policy index (MPI), which has been calculated from a combination of the quantitative and qualitative instruments used by the People’s Bank of China (PBOC). Chapter 5 estimates a monetary policy or “Taylor type” rule for China to examine the reaction of the monetary authority to macroeconomic targets. Finally, Chapter 6 concludes, provides scope for policy actions and responses, points out limitations with the thesis and describes plans for future research.
Declaration

I, Paul G. Egan, declare that this thesis and the work presented is my own. Results and findings have been generated by me as a result of my own original research. I have made due acknowledgement to the work of others.

Signed........................................................................................................

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19.1 F&A.
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List of Abbreviations

ADF  Augmented Dickey Fuller
AR   Auto Regressive
ARMA Auto Regressive Moving Average
BIS  Bank for International Settlements
BOEBR Bank of England Base Rate
BP   Bai-Perron
CCP  Chinese Communist Party
CPI  Consumer Price Index
DW   Durbin Watson
EIU  Economist Intelligence Unit
EOINA Euro Overnight Index Average
GDP  Gross Domestic Product
HMKPC Hybrid New Keynesian Phillips Curve
IFS  International Financial Statistics
IMF  International Monetary Fund
IS   Investment Savings
LM   Lagrange Multiplier
MA   Moving Average
MP   Monetary Policy
MPI  Monetary Policy Index
MPT  Monetary Policy Transmission
MS   Markov Switching
NEER Nominal Effective Exchange Rate
NKM  New Keynesian Model
NKPC New Keynesian Phillips Curve
NPC  National People’s Congress
NPL  Non Performing Loans
OECD Organisation for Economic Co-operation and Development
OLS  Ordinary Least Squares
OMO  Open Market Operations
PBOC People’s Bank of China
PC   Phillips Curve
PRC  Peoples Republic of China
RMB  Renminbi
RMSE Root Mean Squared Error
RRR  Reserve Requirement Ratio
S.D. Standard Deviation
SAFE State Administration of Foreign Exchange
SRAS Short Run Aggregate Supply
SSM  State Space Model
TFP  Total Factor Productivity
TPC  Triangle Phillips Curve
TVE  Town & Village Enterprise
UCM  Unobserved Components Model
VAR  Vector Auto Regressive
WTO  World Trade Organisation
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Chapter 1. Introduction

1.1 General Context

China’s economic achievement over the past three decades has been remarkable. It has managed to maintain a sustained period of unprecedented growth since its reform and ‘opening-up’ policies, first adopted in 1978. The Chinese economy has become as important an engine of growth in the global economy as the United States and the EU over the last decade, and so, understanding the fragilities in areas such as its macroeconomic and institutional systems is more important than ever before. No longer can China be viewed as a country that warrants only specialist investigation. It has arrived on the global stage as an economy that needs to be analysed and assessed in order to gain a general view of the global economy (Yueh 2010). Due to this ever growing importance in the global economy, the issue of how China can sustain its economic growth and maintain macroeconomic stability is of great interest, not only for China itself, but also for the rest of the world. The rapid rise as a global economic power within a timespan of thirty years is often described by analysts as one of the greatest economic success stories in modern times. In an effort to awaken a dormant economic giant, the Chinese authorities introduced reforms that encouraged the formation of rural enterprises and private businesses, liberalised foreign trade and investment, relaxed state control over prices, invested in industrial production and the education of its workforce. By nearly all accounts, the strategy has worked spectacularly (IMF 2012). Since the introduction of the reforms in 1978, China has experienced average annual GDP growth of nearly 10% and an estimated 500 million people have been lifted out of poverty.

Despite the obvious success of Chinese economic policy, there are serious concerns that it may be unable to sustain the model of economic growth it has relied on over the last two decades. There are also many that suggest that China should not seek to sustain such a growth path given the possible side effects (Fukumoto & Muto 2011). Since the 1990’s, China’s growth model has become characterized typically by the demand side components of GDP. Expanding investment and exports have been a major and increasingly important driver of GDP growth, particularly in the last decade. Since 2000, investment increased its overall share of GDP from 35% to 48%, prior to the global financial crisis. Net exports as a share of GDP have also experienced a rapid increase in this period (see Figure 1, page 12). The unusually high rate of investment, as well as the growth in net exports, has corresponded
with a decrease in consumption as a share of GDP from 62% to 48% over the same period. An over reliance on exports and investment over the last ten to fifteen years has led many analysts to believe that China’s growth pattern has exhausted its potential. If consumption cannot increase to play a much larger role in aggregate demand, given the constraints on exports and the limits to investment led growth, then China’s rapid growth will slow down or even stop at some time in the near future. Not surprisingly, the sustainability of the Chinese growth model has been questioned, particularly among policymakers in China itself (IMF 2011). The 12th Five-Year Plan¹ (2011-2015), approved by the National People’s Congress in March 2011, stated that in the next five years China needs to transform its model of economic development substantially to one in which consumption, investment, and exports harmoniously sustain economic growth (Fukumoto & Muto 2011). There have also been calls for a rebalancing of the growth model from commentators outside of China. A 2011 IMF Spill Over Report² found that China’s capacity to both transmit and originate real shocks is rising, implying an important stake for the world in its stability. Therefore, insofar as its export and investment oriented growth model is a source of stresses, economic rebalancing is crucial.

While rebalancing the growth model has been on the top of the list of government priorities for many years, the sharp decrease in exports and investment during the financial crises emphasised the importance to Chinese decision makers of moving to a more balanced growth structure. To achieve this goal, China will require significant changes in both its monetary and exchange rate policy. This presents a key challenge for Chinese authorities; maintaining the balance between the new growth model, maintaining economic growth and controlling inflationary pressure through its monetary policy actions. It would all seem to suggest that the era in which China enjoyed very high growth, coupled with low inflation, is over and that Beijing will have to endure higher inflation and sacrifice some growth in order to keep the economy going (Anderlini 2010). The effect that rebalancing economic growth in China will have on the rest of the world is also an intriguing question. The proposed rebalancing policies are expected to have a significant effect, not only on China itself, but also on its global trading partners. The rebalancing policies will include measures such as realigning relative prices, gradually adjusting the exchange rate and changing the savings

¹ The Five-Year Plan of People's Republic of China (PRC) is a series of economic development initiatives first introduced in 1953. The current instalment was released in March 2011.
² IMF Spill Over reports explore the external effects of policies in systemic economies, focusing on issues raised by key partners (IMF 2011).
behaviour of households and corporations. The effect of possible spill overs arising from these policies will be interesting, for example, how will RMB revaluation affect China’s main trading partners and will it serve to reduce global current account imbalances, as has often been speculated?

Given the issues and challenges that the Chinese economy faces in the future as it plots out the next generation of economic reforms, it is of crucial importance that researchers and policy makers fully understand the dynamics of Chinese monetary policy and macroeconomic fluctuations. The objective of this thesis therefore is to examine inflation dynamics, test the transmission channel of monetary policy and examine the mechanism through which monetary policy affects the real economy in China. While studies of this nature have been carried out extensively for advanced economies using standard New Keynesian (NK) models of monetary policy, the unique characteristics of the Chinese economy and the structure and philosophy of the PBOC pose many challenges for potential research in the area. Therefore, this thesis will examine if researchers and policy makers alike can use augmented versions of standard macroeconomic models to examine inflation, output and monetary policy dynamics in China, just as they have been used in developed economies.

1.2 Methodology

*Three Equation New Keynesian Model (PC-IS-MP)*

Modern macroeconomics is based on what is widely known as the three-equation New Keynesian (NK) model (Clarida et al 1999 and Woodford 2003). This is also often referred to as the Phillips Curve (PC), Investment Savings (IS) and Monetary Policy (MP) model, or the PC-IS-MP model. Its adoption as the backbone of the medium scaled models currently developed by many central banks and policy institutions is a clear reflection of its success\(^3\)

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\(^3\) It is, however, important to mention that there is a fairly substantial body of literature which criticises the New Keynesian models usefulness in terms of quantitative policy analysis. For example, in opposition of these New Keynesian models Mankiw (2006) states that “From the standpoint of macroeconomic engineering, the work of the past several decades looks like an unfortunate wrong turn”. In a more recent paper, Chari et al (2008) argue that the shocks and other features of these models are not structural or consistent with microeconomic evidence. Since an accurate structural model is essential to reliably evaluate the effects of policies, the authors conclude that New Keynesian models are not yet useful for policy analysis. The Financial Crisis which followed seemed to reiterate these arguments and have been strengthened by the work of Buitert (2009), Borio (2012) and Cole & Malini (2014).
This thesis will adopt an augmented version of this model to analyse macroeconomic and monetary policy dynamics in China while taking the specifics of the Chinese economy into account.

The standard three equation NK model contains the below equations:

1) A Phillips curve
\[
\pi_t = \pi_{t-1} + \lambda (\bar{y}_t) + z_t
\]  
(1)

This simple Phillips curve equation states that the inflation rate, \( \pi_t \), is dependent on the lag of inflation \( \pi_{t-1} \), the deviation of output from its natural or potential level \( \bar{y}_t \) and a supply shock \( z_t \). The variable \( \bar{y}_t \) is often referred to as the level of excess demand or most commonly, the output gap.

2) An Investment-Saving (IS) curve
\[
\bar{y}_t = \bar{y}_{t-1} - \alpha (i_t - (\pi_{t-1})) + v_t
\]  
(2)

The IS curve equation represents the level of output as a percentage of its natural or potential level, \( \bar{y}_t \), as depending on a lag of the output gap \( \bar{y}_{t-1} \), the real interest rate \( (i_t - (\pi_{t-1})) \) and an aggregate demand shock \( v_t \).

3) Equations 1 and 2 illustrate how inflation depends on output and supply shocks and output depends on interest rates and shocks to aggregate demand. The model can then be completed by describing how the central bank or monetary authority sets its interest rate. This can be represented by a monetary policy rule, often called a Taylor (1993,1995) rule.
\[
i_t = \bar{r} + \pi_t^* + \beta (\pi_t - \pi_t^*) + \theta (\bar{y}_t)
\]  
(3)

The rule states that \( i_t \), the nominal interest rate (representing the monetary policy instrument) will rise if the inflation rate \( \pi_t \) climbs above its target rate \( \pi_t^* \) or if the [output gap](https://example.com) used in this thesis see Appendix B, page 134.

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4 The details of this brief overview of the PC-IS-MP New Keynesian model were obtained from Whelan (2015). A more detailed theoretical explanation for each equation will be discussed in detail in the individual empirical Chapters 3, 4 & 5.

5 Please note that \( \bar{y}_t = (y_t - y_t^*) \) where \( y_t \) is the actual level of output and \( y_t^* \) is the potential level of output. For more details on the output gap used in this thesis see Appendix B, page 134.
level of real output $y_t$ rises above its natural level $y^*_t$. In the above equation, $\beta$ represents the sensitivity of the interest rate when actual inflation deviates from the target rate; $\vartheta$ on the other hand denotes the sensitivity of the interest rate to the output gap.

One feature of the standard New Keynesian (NK) model framework is that it generates equations that do not relate current variables to lagged variables. While theoretically, the estimates of Equations 1 and 2 are purely forward looking i.e. with the use of rational expectations for both inflation and output, there has been a well-documented failure to obtain robust estimations in the forward looking models (Paradiso et al 2013). Empirically, the backward looking specifications of Equations 1 and 2 often produce estimates that are more consistent with the data (Lindè 2001, Rudebusch 2002 and Goodhart & Hofmann 2005). Studies such as Roberts (2005) and Fuhrer (1997) also find the important empirical role for lagged variables in the NK model. Therefore, in this thesis’s estimations, a purely backward looking specification is applied for the inflation and output equations to obtain dynamics that match those of available economic data most consistently. This is appropriate as actual data usually shows a high degree of persistence in both inflation and output (Estrella & Furher 2002). According to Ball (1999), the advantage of the backward looking specification is that it is “similar in spirit to the more complicated macro models of many central banks”.

There is another theoretical reason why this research opts for a backward as opposed to a forward looking specification. The inclusion of backward looking terms allows us to examine the effect that institutional reform and structural change has had on inflation and output persistence in the Chinese economy. This is a particularly relevant issue to emerging and transition economies. In a Bank of International Settlements (BIS) report, Moreno & Villar (2010) state that persistence has posed a major challenge for monetary authorities in Emerging Market Economies (EME’s) in recent years and is believed to be a factor behind the failure of stabilisation programmes in EME’s seeking to end periods of high inflation.

**China “Specific” Characteristics**

It must be emphasised once again that any research modelling the Chinese economy needs to take the “specific” Chinese characteristics into account. The NK model of monetary policy was developed for advanced economies such as the US and the UK and therefore would not be appropriate for the Chinese economy in its original format. Empirical observations suggest that due to economic reform, structural impediments and limited development of the
financial sector, examining the dynamics of monetary policy in China requires an alternative approach. In fact, the literature has proven that there are many issues in estimating models of China’s macro-economy using standard equations (Gerlach & Peng 2006, Conway et al 2010 and He & Pauwels 2008). While models such as the three equation NK model can be used as a benchmark or “spring-board” to estimate a model of inflation, output and monetary policy dynamics in China, these models need to be augmented to fully capture the unique characteristics of the Chinese macro economy. This constitutes the main contribution of this PhD thesis. The thesis constructs a unique set of macroeconomic models that attempt to account for the idiosyncratic nature of the Chinese economy. While it would be impossible to account for every specific or peculiar characteristic of the Chinese economy during the reform era, the thesis identifies three essential modifications that need to be made in the context of the NK model. The central research question therefore asks that given these modifications, can variations of standard macro models be used to accurately build a representation of the Chinese economy.

1.3 Summary

Overview of Research Question

This thesis will estimate a three equation New Keynesian model which includes some of the key and unique characteristics of the Chinese economy.

- The subsequent chapters will emphasise the importance of the Chinese exchange rate, the Renminbi (RMB) in the empirical analysis. This is done by including changes in the exchange rate as the supply shock in the Phillips curve in Chapter 3. By including the RMB in the model of inflation dynamics, it will examine if the exchange rate has influenced the price level in China, given that the PBOC has both price stability and exchange rate stability as its two policy goals. The exchange rate is also included in the monetary policy rule in Chapter 5. As the PBOC has been more reluctant to use the interest rate as an operating target and instead sets intermediate targets for both the money supply growth and the exchange rate, it is crucial to examine what effect the RMB played in the PBOC’s monetary policy reactions.
Chinese authorities have traditionally relied mainly on administrative and qualitative measures in conducting monetary policy, with interest rates playing a less prominent role (Koivu 2008). Therefore, using this traditional one instrument policy to examine the monetary policy reaction and transmission of the PBOC would not be appropriate. This thesis will create a monetary policy index from a composite of instruments which have been used by the PBOC over the last twenty-five to thirty years.

Finally, and perhaps most crucially, the thesis will account for the huge amount of structural breaks, institutional reform and policy change that the Chinese economy has experienced in the reform era. This will be done by estimating linear models that allow for multiple structural breaks and non-linear Markov switching models which permit switching between different states or periods. This will allow us to capture more complex and dynamic patterns in the time series. This is particularly suitable for China’s economic data given the nature of its development during the reform era.

To my knowledge, this research will be the first to incorporate these three key characteristics in a single study of the Chinese macro economy. By incorporating these unique traits, this thesis will examine if variations of a standard macroeconomic framework, which have been used extensively in the literature for advanced economies, can be used to analyse Chinese macroeconomic dynamics. The thesis will also provide a platform for examining other emerging and transition market economies which have been notoriously difficult to study using empirical models. The results of this thesis show that “augmented” versions of these models can be used to estimate business cycle fluctuations in China, as long as the “specifics” of the Chinese economy are accounted for.

The research question of this thesis can therefore be described in the following way;

*Can we improve the understanding of Chinese macroeconomic dynamics using augmented versions of standard macro models? If so, what do the results of these estimations tell us about macroeconomic stability in China and the challenges that the PBOC face as a result of their unique approach to economic stabilization, particularly in the context of future plans for economic reform and rebalancing?*
Structure and Overview of the Thesis

The thesis is structured as follows. Chapter 2 provides a context for this thesis, gives a general overview of the Chinese economy and discusses some of the main macroeconomic indicators. Chapter 3 estimates a Phillips curve for China from 1987-2014 using the econometric techniques described in Appendix A, page 129. The estimations find that the Chinese Phillips curve is not generated by a linear relationship and the curve takes a concave shape. The shape of the Chinese Phillips curve is attributed to the large number of state-owned monopolies that operate in the Chinese economy. A concave Phillips curve points to the declining sensitivity of inflation to the strength of the economy. In other words, the cost of fighting inflation varies systematically depending on the strength of the economy. This would indicate that the lesson for the PBOC in terms of monetary policy would be to consider output cost and policy response on a case by case basis depending on the level of output in relation to potential. The results also indicate that the larger the role of the exchange rate has on Chinese inflation, the less the role that monetary policy has through changes in output. This perhaps points to a recommendation of further flexibility of the RMB. Chapter 4 examines the monetary policy transmission channel in China from 1991-2014 by estimating an IS curve using a composite monetary policy index based on the instruments at the disposal of the PBOC. The results suggested that the monetary policy actions of the PBOC have had less of an effect on the level of output since 1995. While this seems counter intuitive, due to the increased reform in the financial sector as well as measures which have promoted greater PBOC independence, the result is attributed to the adoption of the dollar peg in 1994. Chapter 5 estimates a Taylor type monetary policy rule using the same monetary policy index used in Chapter 4. The exchange rate is also included as the PBOC’s intermediate target. Making these necessary adjustments to account for the specifics of the Chinese economy and its financial system, the chapter aims at improving the understanding of how the PBOC reacts to its main policy target variables. The results suggest that like many other emerging market economies, the PBOC are sensitive to changes in the level of real output. The results also suggest that the PBOC’s monetary policy response is compromised due to their quasi fixed exchange rate policy. Finally, Chapter 6 summarises the results of each individual chapters and suggests relevant policy options as well as discussing future challenges for the Chinese macro economy. It also discusses the limitations of this thesis and gives scope for future research.
Chapter 2. The Chinese Economy - An Overview

2.1 General Background

*Pre Reform China*

Before the outbreak of the Sino-Japanese war in 1937, China had experienced modest but significant growth in the early 20th century with a modern economy underpinned by industry, communications, transportation, banking and finance in which domestic ownership predominated (Brandt & Rawski 2008). This period of economic development was interrupted by both civil and world war. In the immediate aftermath of these wars in the late 40’s, the newly established People’s Republic of China (PRC) inherited an economy whose growth potential and development had been obscured by the ravages of conflict and war and severe macroeconomic imbalances threatened to cripple the economy (Naughton 2007). The new regime, under the predominant leadership of Mao Zedong, set about repairing the serious damage and destruction that had been inflicted on China’s economic infrastructure. Modelled on the Soviet experience, a system of central planning was adopted, new institutions were established, and the economy was organised through annual and five-year plans. The authorities followed a socialist industry priority development strategy, often referred to as ‘the Big Push’ strategy. From this period until the late 1970’s, this ‘Soviet type’ centrally planned economy brought mixed results. The new leaders gained popular support by solving the problems of inflation, infrastructure and by rebuilding many of the war damaged industrial plants. Investment, which was mostly government investment, increased rapidly along with the rate of savings. This promoted economic growth, despite the short term disruptions resulting from The Great Leap Forward and The Cultural Revolution, with an average GDP annual growth rate of around 6% from 1950 to 1978. During this period,

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6 Established in October 1949, the PRC was the culmination of years of battle between Mao Zedong’s Chinese Communist Party (CCP) and the regime of Nationalist Chinese leader Chiang Kai-Shek.

7 An attempt by the People's Republic of China in late 1950's to solve the country's economic problems by labour-intensive industrialization. The plan emphasized decentralized, labour-intensive industrialization, typified by the construction of thousands of backyard steel furnaces in place of large steel mills. Wildly unrealistic objectives, poorly planned communization of agriculture, and a poor harvest in 1959 caused mass starvation.

8 Fearing that China would develop to be too like the Soviet model Mao Zedong threw China’s cities into turmoil in a monumental effort to reverse the historic processes underway. It involved goals such as replacing his designated successors with leaders more faithful to his current thinking and to rectify the Chinese Communist Party (Diao 1970).
China outperformed many of its developing world counterparts, including Brazil, Egypt, India, Indonesia and Mexico, by substantial margins.

Despite some success and development during this era, the Chinese economy also suffered from multiple inefficiencies one would associate with a centrally planned system. There were few profit incentives for firms and farmers, competition was virtually non-existent and price and production controls caused widespread distortion in the economy (Morrison 2012). Despite higher GDP growth in many cases, Chinese living standards were substantially lower than those of other developing countries. It was now clear that the PRC and Mao had failed in their goal to transform China from an agrarian economy into an industrial giant. The death of Mao Zedong in 1976 is seen as a hugely significant event in the context of Chinese economic development, with agreement among the political elite of the need for economic reform. Mao’s successor as leader of the PRC, Deng Xiaoping, began an ambitious programme of economic reform with the aim of raising economic growth and foreign investment (Ma 1996). Although initially these measures involved simply restoring household agriculture (which had been collectivized into large communes in the 1950’s), additional reforms followed in subsequent years with the aim of decentralizing economic policymaking in areas such as trade and investment (Goldman & MacFarquhar 1999). Perhaps most significantly, the state price controls on a wide range of products were also gradually eliminated.

*Post Reform (1978 - present)*

The reforms pioneered by Deng Xiaopeng in 1978 brought with it extraordinary institutional change which has proven to be effective in promoting China’s economic growth and in advancing its international status. It has achieved institutional change in a steady, systematic and staged manner. This has altered its economic system substantially (Tisdell 2009). Since then, the Chinese economy has experienced annual average GDP growth of nearly 10%. It is important to point out that like the reforms themselves, China’s growth came gradually and across different stages. Kotz & Zhu (2010) have identified four distinct stages or periods in the evolution of the Chinese growth model since the reform period began. From 1978-1988 the Chinese government adopted what is referred to as *Balanced, Domestic Market Led Growth*. This began as a simple reform of the agricultural sector in which farmers were given higher prices for the goods they produced by the state. This led to an increase in the income of the ordinary people which enabled household consumption to play
the leading role in GDP growth, which averaged 9.5% over the ten years. The rapid growth in output in the 1980’s lead to the observation that China’s growth began in the countryside (Riskin 1987). Chow (2004) also identifies a number of important factors that contributed to this growth rate during the early reform period. For example, the resourcefulness of the Chinese people in farming, light industry and trade was given opportunity to manifest itself in promoting economic growth. Added to this, the main political structure remained intact during the process, which in turn provided direction and leadership needed for economic reform. As Figure 1 (page 12) illustrates, consumption was the main component of GDP, accounting for 65% in the ten year period (1978-88) and thus playing the leading role in GDP growth. The period 1988-1991 is described by Kotz & Zhu (2010) as an Investment Led Slowdown, where China experienced a significant decline in fixed investment. The cause of this slowdown stemmed from some of the reform processes which were implemented in the previous period. Reforms in the banking system caused a huge increase in the money supply which led to enormous inflationary pressures. This was to result in the social unrest and discontent that eventually led to the Tiananmen Square event. In response to these developments, the government was forced to cut state investment and undertake other measures in an attempt to cool down the economy. As Figure 1 shows, investment decreased from 37% in 1988 to 34% in 1991. While the inflationary pressure slowed, so did GDP growth, averaging 5% over the three year period. From 1991-2001 China adopted a policy of Investment Led Growth, which can be attributed to the cooling of inflationary pressure, added with shifts in government policy. With the spiralling inflation of the previous period now under control, the government was free to ease the restrictive policies which had been put in place in order to promote GDP growth once again. This was echoed in Deng Xiaoping’s famous southern tour in January 1992\(^9\), in which he called for further economic reform in an attempt to accelerate the county’s growth. During this period, China’s economy grew at 10% per year with investment accounting for 39% of GDP. China’s exchange rate policy also began to play a huge role in China’s growth trajectory during this period and would become a huge talking point between China and its main trading partners in the preceding years\(^{10}\).

\(^9\) The Chinese leader visited the Southern coastal provinces where he promoted economic reconstruction and a more market driven approach of boosting the economy. The tour is considered to have had far reaching consequences for the country’s economic development.

\(^{10}\) China’s exchange rate policy and its effects will are discussed in Section 2.3.3 (page 29).
Finally, the period from 2001 up to present has seen China adopt what has been called an Export and Investment Led Growth strategy. It is during this period that China’s current pattern of growth based on a combination of external demand and investment was established, with fixed investment and exports becoming the main factors accounting for growth. This period also coincides with China’s accession to the World Trade Organisation (WTO) in December 2001. This is widely regarded as a major milestone in the development of the Chinese economy as well as the multilateral trading system, as it deepened Chinese integration into the global economy (Chen 2009). China’s economy has experienced high and stable growth during the last decade, with an average GDP growth rate of almost 10% and, in 2010, it overtook Japan to become the world’s second largest economy.

Despite the obvious success of Chinese economic reform policy, there are serious concerns that they may be unable to sustain this current model of economic growth much longer. As Figure 1 indicates, domestic investment and exports have played an ever increasing role in economic growth over the last decade. This has corresponded with a decrease in the role played by consumption which stood at just 48% in 2014. This is unlike most developed world economies in which final consumption accounts for up to and over 70% of GDP. Another important source of GDP growth in this period has been external

**Figure 1 – Components of China’s GDP**

*Source: China National Bureau of Statistics (NBS) & author’s calculations*
demand. China’s net exports as a share of GDP have increased rapidly during this period from 2.6% in 2002 to as high as 8.8% in 2007. While this rate was dampened by the global economic downturn (7.7% in 2008 and 4.3% in 2009), the Chinese government responded by increasing incentives for exports such as raising tax rebates for exporters as well as increasing the investment share of GDP from 42% to 47% during the financial crisis. For this reason, China did not suffer as severe a recession as experienced in Japan and most of emerging Asia in 2009. Exports also grew much faster than imports in this period (2001-15) which inevitably led to a huge trade surplus, and with it, increasing pressure from its major trading partners to allow its currency to appreciate. While exchange rate reform in 2005 saw some level of appreciation of the Renminbi, many of China’s trading partners, particularly in the US and EU, have criticized this pace as being too slow given China’s strong economic growth over the past few years particularly in its trade sector, not to mention its rising level of foreign reserves, which hit $4.3 trillion as of 2015 (see Figure 10, page 36)

It has become apparent that the investment and export led growth policy, on the back of a weak currency, has become unsustainable. Speaking in 2011, then Chinese Premier Wen Jiabao echoed this sentiment when he stated that the Chinese economy has become ‘unsustainable, unbalanced’ and that it ‘lacks co-ordination’. Continuing down the investment and export led growth path, particularly with recent inflation pressure is no longer a viable option and it is possible that China will face a sudden slowdown unless it undergoes urgent political and economic reforms.

2.2 China’s Economic Reforms

China, like many other emerging market economies (EME’s), has gone through a significant process of economic reform. It must be said however that the Chinese economy has experienced more changes and institutional amendments than any other modern economy in transition. The economic reforms were introduced under the leadership of Deng Xiaoping. Xiaoping held various senior titles in the Chinese Communist Party (CCP) including Vice Chairman of the Central Committee before becoming the effective leader of China in 1978 and is often dubbed the “father of modern China”. At the outset of his ambitious plans, he famously stated that the purpose of the systematic reform of the Chinese economy was aimed at reaching “socialism with Chinese characteristics”. The Chinese economy has been
completely transformed from one that was devoid of almost any market forces prior to 1978 to one which is close to being fully marketised. It has switched from an economy which had little or no foreign investment or international trade to being the global centre of foreign investment projects and the world’s largest exporter. The complexion of the Chinese economy has been completely changed, and not solely since 1978. Perhaps the biggest transformation in China’s position in the global economy has occurred over the last twenty-five years. An article in *The Economist* (11th March 2015)\(^{11}\) stated that in 1990 China produced less than 3% of the world’s manufacturing output by value. By the end of 2014, this had increased to over 25%. In 1990, China’s GDP meant that it ranked outside the world’s top ten economies. Today, it is the world’s second largest economy. In fact, an IMF forecast at the end of last year stated that, by their estimates, the Chinese economy is now worth $17.6 trillion, slightly higher than the $17.4 trillion estimates for the US\(^{12}\). The monumental leap that the Chinese economy has made over the last two decades would not have occurred if not for the systematic reforms introduced in the late 1970’s. It is important to emphasise that these changes and reforms were not in the form of a one-off policy or a “big bang” change in institutional systems and philosophy. China adopted its reforms gradually or incrementally during this period. By so doing, it has phased in market forces into an administered economy but without a fundamental ownership transformation into a privately owned economy (Yueh 2010). The reforms of the Chinese economy are often characterised into two distinct periods or “eras”.

*First Era of Reform (1978-1992)*

China’s market transition began at the end of 1978 with a wide-ranging reassessment of nearly every aspect of the command economy (Naughton 2007). The first phase of these reforms took place in the early 1980’s and began with the agriculture sector, a sector which had long been neglected by the CCP. This began with the implementation of the contract responsibility system in agriculture, by which farmers were able to retain surplus over individual plots of land rather than farming for the collective. This was followed by the establishment of township and village enterprises (TVEs) whose ownership was not under the state but by the rural towns and villages (Liang 2006). State owned enterprises also began to

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be influenced by the reforms. One of the earliest of these reforms was to give state owned enterprises autonomy in production, marketing and investment decisions rather than simply following state instructions as under a system of central planning. During this period, SOE’s were also made financially independent and were now allowed to keep their earnings as their own profits after paying taxes to the state, rather than as revenue belonging to the government as had been before (Chow 2004). There were also important reform in both the price system and the banking and financial system during this period. Given their importance to the overall context of this thesis, these will be dealt with separately in Sections 2.3.1 (page 19) and 2.3.3 (page 29) respectively. This first period also saw China take up membership of both The World Bank and the International Monetary Fund (IMF). Perhaps the most significant event of this reform period however was the “opening up policy” by which China interacted economically with the outside world. Exports, imports and foreign capital were now part of China’s long term plan for future economic development. This part of China’s economic reform involved key steps with regard to foreign trade and investment. First of all, the government decentralized decision making regarding exports and imports to local governments or regional foreign trade corporations (Qian & Wu 2000). In 1980, a series of special economic zones (SEZ’s) and coastal open cities, namely Zhuhai, Xiamen, Shenzhen, and Shantou, were also designated for the purpose of stimulating exports and attracting foreign investment. Administrative restrictions on exports and imports were replaced by tariffs, quotas, and licensing. Controls on foreign exchange were also loosened over the years, particularly for foreign-invested managed firms (Wei 1995). At first, foreign business were only permitted in the four SEZ’s, but in successive waves, the number of “open areas” increased to fourteen open cities, the Yangtze and Pearl River deltas and successively larger areas (Naughton 2008). Foreign investment now started to become an important part of the Chinese economy. Foreign investors could now set up factories in these special zones and could take advantage of the inexpensive and skilled labour that the local population could provide. The local population reaped the benefit of market determined wage rates which were higher than the rates prevailing in other parts of China (Chow 2004).

These early reforms that began in 1978 drove China’s transition process through the 1980’s and set the foundation for the 10% annual growth rates that followed in the three preceding decades. Chow (2004) is quick to point out that without the growth that was fuelled by the early economic reforms, further far reaching reforms would not have taken place as the reform leaders would have lost the confidence and support of the Chinese people and, perhaps more importantly, the CCP.
Second Era of Reform (1992 onwards)

At the outset of the reforms, the PRC’s reform goal was to simply increase productivity and improve living standards, but at no time did the leadership think it was going for a full market system (Perkins 1994). This process however began with the reforms that took place in the early 1990’s – a period often referred to as the Second Era of Chinese reform. The reform era had entered a new phase in which China’s economic transition was expanded and advanced. This was echoed in Deng Xiaoping’s famous southern tour in January 1992, in which he called for further economic reform in an attempt to accelerate the county’s growth. During this period, China’s economy grew at 10% per year with investment accounting for 39% of GDP.

The strategies undertaken in this period were very different than those that had proceeding them in the previous decade. Instead of a focus on local township and village enterprises in the vast rural regions, the reforms shifted to large scale industrial development in the coastal provinces. This was often funded by state led investment drives which were fuelled by foreign direct investment funnelled into the SEZ’s (Huang & Yang 1996). Reforms which scrutinized the discipline and governance of often inefficient state owned enterprises (SOE’s) were also introduced. This included an important charter at the Thirteenth Congress of the Chinese Communist Party in 1987 which recognized the private sector as a necessary supplement to the state sector. It also began to transform SOE’s into “modern enterprises” with “clarified property rights, clearly defined responsibility and authority, separation of enterprises from the government and scientific privatization of SOE’s” (Qian 1999). The reform agenda was also widened to include fiscal policy as well as foreign trade policy. The latter saw the Chinese economy increasingly integrated with the world market culminating in China’s accession to the World Trade Organisation (WTO) in 2001 (Bell & Feng 2013).

The Second Reform era also saw important institutional changes in the banking and financial sectors which were hugely significant in the development and progress of the Chinese economy in the 1990’s and 2000’s. In 1994, the Chinese government launched a series of macroeconomic reforms encompassing central banking and exchange rate management (Hwa 2008). The exchange rate was re-valued and eventually pegged to the US dollar (USD) until 2005. Monetary policy authority was taken out of the hands of local government administration and the PBOC was given much greater power and authority. The
focus was to create a viable banking system which could control the economy via monetary policy and issue loans on the basis of profit and loss, rather than by political orders (Bank of International Settlements 1999). The development and reform of China’s financial and banking system will be discussed in greater detail in Section 2.3.3 (page 29) and Chapter 4 and 5 of this thesis.

The Economics of Reform and Structural Change,

In large part due to the institutional reforms and increased industrialisation that came with them, the Chinese economy has experienced massive structural transformation over the last three decades (Fan et al 2003). Taking account of the fact that the Chinese economy has experienced such change in both its institutional structure and economic policy, there is a general consensus that any study of macroeconomic relationships in China will suffer from structural breaks and non-linearity.

A structural break can simply be defined as a sudden event in time which will ultimately change the structure of the econometric model under consideration. Macroeconomic models are vulnerable to structural change in at least two related ways. Firstly, parameters can shift, introducing errors into historically estimated relationships. Secondly, macroeconomic models are generally based on a limited set of causal relationships, which may have been relevant in a historical period but can become irrelevant over time (Basdevant & Hargreaves 2003). Fidrmuc & Tichit (2009) provide strong evidence of the issue of structural breaks in macroeconomic data during an economies transition process. The authors therefore argue that empirical analysis of transition economies must account for the possibility of structural changes; otherwise inferences made from estimations will be misleading. An IMF (2014a) report also states that structural changes in the financial system could affect the stability of a model of the macro economy. For example, financial innovation and liberalisation could alter the link between money aggregates, output and interest rates which makes monetary aggregate targeting less effective.

Non-linearity on the other hand provides a very different interpretation of shocks of macroeconomic variables depending on the state of the economy (Koop & Potter 1999). The asymmetric reaction of macroeconomic variables in this manner is also symptomatic of an

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The issue of asymmetry in macroeconomic relationships is not just a China specific problem. Many transition and emerging market economies experience nonlinearities when it comes to the monetary policy reaction of its central bank. From the perspective of a typical transition economy, some important features of monetary policy in transition, such as shifting preferences and nonlinearities of policymakers' choices, have been largely ignored in the existing literature. However, as noted by Hamilton (1989) and Surico (2007b), central banks may have asymmetric preferences in reality, which gives rise to the existence of a nonlinear monetary policy reaction function (Ma 2014). In the Chinese case, Liu (2003), Liu and Wang (2003) and Liu & Zhang (2010) are all separate examples of papers that identified the business cycle phases between recessions and expansions in China using different nonlinear methods.

With respect to the presence to both structural breaks and non-linearity in macroeconomic time series, brought about by structural and institutional change, a useful and well used approach is to use models with changes in the mean. Among the “switching“ models that have been used extensively for this purpose are the Markov switching model developed by Hamilton (1989,1994) and the multiple breakpoint model developed more recently by Bai & Perron (1998, 2003). Both models are useful for modelling structural change and have differences that allow researchers to examine different characteristics. First of all, the multiple breakpoint model can tell us how the dynamics of a particular variable are changing over time. For example, it can examine if relationships between macro variables in China has changed from the first era of reform (1978-1992) and the second era of reform (1992-2014). However, macroeconomic relationships do not just change over time, but may also display distinct patterns under different states or regimes. The Markov switching (MS) model allows us to examine these relationships. These techniques will be discussed in greater details in the empirical chapters – 3, 4 and 5 – but a general overview is provided in Appendix A (page 129). Using two different “structural change models” will provide us with a much better understanding that standard models with stable parameters. As China’s economic variables exhibit sudden changes brought about by economic reform, modelling these variables using constant coefficients would lead to incorrect specification, inaccurate forecasts and inevitably incorrect policy responses.
2.3 China’s Macroeconomic Indicators

This section of the thesis gives an overview of the main macroeconomic variables which make up the three empirical chapters i.e. inflation, output and monetary/exchange rate policy.

2.3.1 Consumer Prices & Inflation

Price Reform

In the pursuit of reform to the overall economic structure of the Chinese economy, policymakers have always attached a great deal of importance to price reform. As part of the “Decision of the Central Committee on Economic Reform” adopted in October 1984, the importance and position of price reform to China’s economic restructuring was clearly described. This landmark “decision” pointed out that price was the most important regulatory means and the reform of the price system was the key to the success or failure of the overall reform structure (Jin & Qian 1996). The main objective of these reforms was to decontrol the administratively determined prices gradually and allow prices to be determined by market forces (Chow 2004). However, the Chinese government, aware of the problems that immediate liberalisation to prices might cause, decided to introduce a two tiered or “dual track” pricing system. Introduced in the early 1980’s, this system involved the features of the planned economy running simultaneously with the establishment of a free market system. The Chinese government allowed some state owned enterprises, which had reached or surpassed the production quotas as set out by the planned system, to sell their excess output at market prices, with the quota production remaining at the state set prices. Qian (1999) refers to this dual track pricing system as “price liberalisation at the margin”. In other words, economic agents were now allowed to participate in the market place at free market prices as long as they had fulfilled their obligations under the planned system. This first step in the

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14 In order to implement the strategic planning adopted at the National Congress of the Communist Party of China, the Plenary Session of the Central Committee of the Communist Party of China discussed some major issues concerning deepening the reform comprehensively, and made a number of key decisions based on the discussions.

15 Prior to the adoption of reform in 1978, prices of almost all commodities in China were decided by government.

16 Chow (2004) argues that these problems would have included a sudden increase in prices by market forces of essential consumer goods which would affect the welfare of consumers and the disruption of state enterprises who for years had been supplied with low cost inputs under the centrally planned system.
direction of price liberalisation meant that both market prices, and the market for goods and services itself, became important resource allocation institutions in the very early stages of the reform process. It also meant that enterprises involved in the system were incentivized to maximise their inputs outputs and profits, thus aiding economic growth (Yuan 1999).

Prior to the adoption of these reforms in 1978, the prices of almost all commodities in China were decided by the government. According to The National Bureau of Statistics (NBS) in that year, 97% of all commodities sold by retail were decided centrally. Less than twenty years later in 1994, it was evident there had been a huge change in price determination by which time 94% of all retail commodities were determined by market forces. Indeed, by the end of the 1990’s, nearly all prices had been liberalised and those that remained under state control were adjusted towards market levels (Oppers 1997). Price liberalisation became a key driver of China’s economic reform throughout the 1980’s and 1990’s with important price deregulations in 1985, 1989 and 1994 (Mehrotra & Sanchez-Fung 2010). It must be noted however, that even as of 2015, there are a several goods in China whose prices are heavily regulated. These range from tobacco, teaching materials, basic telecommunication services, medicine, natural gas, water, electricity and postal services. However, in the spirit of price reforms which began back in the late 1970’s, the National Development and Reform Commission (NDRC) have stated that 80% of the commodities and services still under price regulation would be liberalised by the end of 2016.

Inflation in China

Consumer price inflation is among the primary problems confronting transition economies (Maxfield 1997). China has been no different in that regard. Bell & Feng (2013) offer a variety of reasons for this including the readjustment of the price system, the Chinese government’s high growth model as well as the rising household and business debt brought about by a more market determined economy. Figure 2 (page 21) depicts the annual growth rate of CPI inflation in China from 1987 to 2014. From a simple graphical analysis, it is clear that there have been five pronounced peaks of Chinese inflation in 1988, 1994-95 and more modestly in 2004, 2008 and 2011. There have also been periods of deflation in 1998 to 1999

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17 Oppers (1997) points out however that the late 1980’s also saw great setbacks in the price reform process. For example, Chinese authorities, in response to macroeconomic imbalances, introduced a “rectification” programme which included a part reversal of earlier price reforms. Naughton (2007) argues that this is one of the many tensions which led to the Tiananmen Square incident of 1989 which further interrupted reform.

and again in 2001 to 2002. These variations in the price level coincided with a relatively stable real growth rate which fluctuated around 9% for the period. It would also appear that Chinese inflation is characterised by two separate periods - the period 1988-1995, which saw high and volatile inflation and 1995-2014 which saw relatively low and stable inflation.

**FIGURE 2 – CPI INFLATION RATE 1987Q1-2014Q3**

As mentioned in the previous section, with the onset of the reform period, prices in China were gradually liberalised and deregulated. One of these deregulations occurred in 1987 and led to a huge increase in the price level, with inflation reaching 25%. The People’s Bank of China (PBOC) responded by introducing contractionary monetary policy in an attempt to dampen this increase in prices. While Figure 2 shows that this policy was successful in curbing inflation, it proved to be overly effective and led to low GDP growth in the proceeding period. Low growth and inflation continued into the early 1990’s. The 1992 period saw further price liberalisation, loosening monetary policy and credit controls by the PBOC. China’s GDP growth rate increased rapidly, as did the inflation rate which peaked at almost 27% in 1994. This was aggravated by the over depreciation of the RMB when the official exchange rate was combined with the free market swap rate\(^\text{19}\) (McKinnon and Schnabl 2009). This was followed by monetary policy tightening by the PBOC towards the

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\(^{19}\) Before 1994, China was still under the “dual” exchange rate regime, under which 80% of the foreign exchange trading volume was at the market rate, and only 20% at the official rate. The 8.7 RMB per USD rate was basically the market rate at the end of 1993. On January 1, 1994, China unified the “dual” exchange rate regime into a single one.
end of 1994. Inflation then decreased almost as fast as it had increased in 1995. The adoption of a fixed exchange rate peg with the dollar, following a period of large devaluations, also helped to reduce inflation volatility. China’s inflation has remained surprisingly low for more than a decade since then and has even included two periods of deflation. This has all been set against the backdrop of rapid economic and credit growth. The last fifteen years can therefore be characterised as China’s low inflation period, with an average inflation rate of less than 3%.

While Chinese inflation has remained relatively low and stable over the last decade, inflationary pressure has not completely dissipated. China’s inflation grew from moderate levels to over 6% in 2011 and again in 2012. This surge in Chinese inflation occurred during a period when foreign interest rates dropped sharply relative to domestic rates, and some commentators believe this increase in the price level was a direct result of a monetary policy trade-off between “sterilization20” costs and price stability (Chang et al 2014). As a corollary, the inflation rate at the time of writing this chapter (2015Q1) was as low as 0.5%, despite GDP growth of 7.5% over the same period. The seeming inability of monetary policy to maintain inflation at the desired level is often blamed on the “impossible trinity”21 theory. For example, Glick & Hutchison (2009) argue that China faces the problem of pursuing independent monetary policy and limited exchange rate flexibility, while at the same time facing large and growing international capital flows.

**China’s Price and Inflation Data**

Like all Chinese macroeconomic data, China’s inflation data suffers from the problem of quality and reliability. While the dual price system introduced in the early 1980’s drastically improved the working of the price mechanism, the truth is that the reliability and availability of Chinese inflation data has never been up to the quality of advanced economies. The issue of Chinese data quality has been well documented (Rawski & Xiao 2001, Brandt & Rawski 2008 and Holz 2014). The main problem with the accuracy of price level data is that China does not explicitly detail how it calculates its consumer price index (CPI). The World Bank (2012) criticised China’s refusal to release full details on the weighing it gives to different

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20 Sterilisation is a process by which a monetary authority seeks to limit the effect of inflows and outflows of capital on the money supply. Further details are given in Section 2.3.3 (page 34 & 37) and Chapter 5 (page 110-111).

21 The impossibly trinity states that an economy may choose two but not all three of the policy goals of monetary policy independence, a fixed exchange rate and full capital mobility. See Section 2.3.3.
product categories when calculating inflation. The composition of the price basket can have particular relevance to Chinese price levels as there is often a huge gap between China’s food inflation and general inflation (Koch-Weser 2013). This is highlighted in Figure 3. From the information released by official sources, it is apparent that a selection of key goods and services are excluded from the calculations. These include services such as accounting, IT and advertising. Another key problem with the inflation rate in China is the different price levels across the various regions of China, with the urban-rural price index differences often particularly high (see for example Xuechun 2010). This brings its own problems when it comes to accurately estimating the Chinese inflation rate. For example, regional governments are often accused of reporting incorrect price level data to its superior statistically offices. The remaining regulation of certain prices mentioned earlier also causes problems in interpreting an accurate level of inflation. This is compounded by the fact that there are still many state owned enterprises which are heavily subsidised which distorts the price level further. The Economist (April 2013)\(^\text{22}\) reported that China provided subsidies of close to $28billion between 2001 and 2011 to the auto part industry and $33billion between 2002 and 2009 for the paper industry.

**FIGURE 3 – CPI INFLATION RATE 1994Q1-2014Q4**

![CPI Inflation Rate Chart](image)

Source: National Bureau of Statistics (NBS) and OECD

Despite the above challenges to inflation data in China, considerable progress has been made to improve the overall quality and reliability of Chinese statistical data. Scheibe and Vines (2005) state that, in particular, the NBS is trying to publish accurate, unbiased and quality economic data for China. We therefore use this database as our primary source of Chinese data where possible.

### 2.3.2 Output and Employment

*China’s Rapid Growth – Success and Challenges*

After more than thirty years of sustained economic growth, China has become the world’s second largest economy (or arguably the largest, see page 14). From 1979 to 2014, China’s real GDP grew at an annual rate of nearly 10%. It is estimated that during this period, close to 500 million people in China have been raised out of extreme poverty (World Bank 2015). In fact, the huge growth in employment and rapid increase in labour and worker productivity has been a major driving force in the economic success of the Chinese economy. The sheer enormity and scale of China’s growth is emphasised in Figure 4.

**Figure 4 - China’s Real GDP Annual Growth Rate**

*Source: Oxford Economics, China’s National Bureau of Statistics (NBS) & Author’s Calculations*
Despite the obvious success of China’s output growth, it still remains a developing country, with a GDP per capita of just $6,800. Since the early 1990’s, China’s growth model has been characterised typically by the demand side components of GDP i.e. investment and exports (see Figure 1) and now some experts argue that China’s growth path has exhausted its potential. Given the constraints on exports and limits to investment led growth, China’s, rapid growth could slow, or potentially, even stop sometime in the near future unless consumption increases to play a much larger role in aggregate demand. China is now at a crossroads, and further reforms are needed to ensure broad, sustainable and equitable growth in the years to come. Concerns have been voiced that the Chinese economy may fail to catch up as rapidly as in the past with the leading world economies, and may get stuck in a so-called middle-income trap\(^{24}\) (OECD 2013). At the same time, Chinese leaders are wary of mass unemployment, like that witnessed in 2008, and the social unrest that comes with it if there is a sudden shift away from China’s labour intensive investment and export component.

**Figure 5 – China’s “Official” Unemployment Rate**

Source: China’s National Bureau of Statistics (NBS)

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\(^{23}\) Article in the Financial Times (December 2010) accessed at http://www.ft.com/intl/cms/s/0/f38e08ce-0e84-11e0-b9f1-00144fcebde0.html#axzz3c5ry3wKX

\(^{24}\) Many emerging markets have grown rapidly at low income levels but were ultimately unable to move beyond middle income status. The troubled global outlook now poses a risk that even dynamic middle income economies like China that are unable to adapt may similarly find themselves trapped (Eichengreen et al 2011)
Economists generally attribute much of China’s rapid growth over the last three decades to two main factors - large scale capital investment financed by large domestic savings and foreign investment rapid productivity growth. These two factors also seem to have complemented one another during China’s economic development. The reforms implemented throughout the 80’s and 90’s led to higher efficiency in the economy which boosted output thereby increasing resources for additional investment in the economy (Morrison 2014). With the aid of these two factors, China has managed to reach its twin targets of economic and employment growth. Lo (2007), however, argues that the actual path of growth that the Chinese economy has followed does not exactly comply with the official objectives of market reform or of “constructing a harmonious society”. In the early years of reform, China’s growth was largely labour intensive owing to the huge transfer of agricultural workers into industry. At the beginning of the reforms in the late 1970’s, a staggering 71% of the overall workforce engaged in agriculture. Following common patterns of structural change, the share of the labour force in agriculture has declined substantially since then and fell below 50% for the first time in 2004 (Naughton 2008). Figure 6 shows the significant shift away from primary sector industry since 1986.

**Figure 6 – Percentage of Workforce by Industry**

![Percentage of Workforce by Industry](image)

Source: China’s National Bureau of Statistics (NBS)

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25 Harmonious society (“héxié shèhuì”) is a concept introduced by former President Hu Jintao of the PRC as a vision or objective for the country’s future socioeconomic development.
This inter-sectorial shift of labour away from agriculture and into industry increased overall productivity and consequently aggregate demand (Bloom et al 2010). The output effects of labour relocation in China in the early reform period has been examined by Sachs et al (1994), Woo (1998) and Cai and Wang (1999). Since the early 1990’s however, China’s growth path has tended to switch to a capital and export dependant one (see Figure 1 page 12). The substitution of capital for labour particularly in industry has become increasingly evident and as a result, the ability of economic growth to create jobs and absorb new labour employment has diminished (Lo 2007). An IMF (2013) report states that China needs to reduce investment over the medium term to facilitate a more sustainable consumption based growth model. This would also require more efficient use of investment. If existing trends continue, valuable resources are likely to be wasted at a time when China’s available finance for investment is reaching its limits. China has also relied heavily on exports for output growth, particularly since the mid 90’s (Figure 7). This also corresponds with China’s accession into the World Trade Organisation (WTO) in 2001. From 2001 to 2010, China’s exports rose nearly 6 times to roughly $1.57 trillion, while imports rose by nearly the same order of magnitude to $1.39 trillion.

**Figure 7 – The Contribution of Exports to China’s GDP Growth**

*Source: World Bank*
In the past, China’s high levels of investment have also created capacity beyond its ability to consume. This has often been absorbed outside its borders by the exceptionally strong global demand for Chinese exports (IMF 2014b). As the global financial crisis highlighted however, China can no longer rely on this blistering level of demand for its exports that it enjoyed in the early and mid-2000’s. The problem of excess capacity can be highlighted by examining the various estimates of China’s output gap i.e. the deviation of output from its natural or potential level. Despite GDP growth which averaged almost 10% since 1978, China’s output gap has remained negative for the majority of the period (IMF 2012 and Appendix B, Figure B.1). This is indicative of a growth model that has relied on high levels of investment and exports combined with surplus labour. Given their importance in the context of this thesis, Appendix B (page 134-138) provides a more detailed discussion on both excess capacity in the Chinese economy and the calculation of the Chinese output gap itself.

The gap between potential and actual output fuels the arguments for rebalancing China’s growth model away from these demand side components towards more sustainable domestic led consumption growth. To ensure a “soft landing” during such a process, the monetary policy reaction of the PBOC will be of paramount importance. This will be discussed at length Section 2.3.3.

**China’s Output and Employment Data**

As mentioned in Section 2.3.1, Chinese economic data is often the victim of uncertainty and unreliability. GDP and unemployment data are one of the variables most prone to this problem. Chinese employment (or unemployment) data is perhaps the most unreliable. Giles et al (2005) emphasise this by pointing out that none of the Chinese estimates of unemployment are calculated in a way that is consistent with standard international practice, making it difficult to be confident in their accuracy. This usually means that China’s official unemployment figures are grossly underestimated. A prime example of this was during the global financial crisis that began in 2008. It was estimated that during the crisis, at least 20 million migrant factory workers lost their jobs. Figure 5 (page 25) however does not indicate any significant change in the official unemployment rate in this period.
China’s GDP data has also been called into scrutiny on several occasions. Perhaps the most widely cited article on this issue is by Rawski & Xiao (2001). The authors state that China’s GDP data contains numerous inconsistencies, especially since 1998. The findings suggest that cumulative GDP growth between 1997 and 2001 was as much as one-third of the official claims. Naughton (2008) also offers an explanation for this discrepancy. Attempting to adjust data collection procedures to an economy with many more small scale businesses, the NBS shifted to sample survey estimates of the size of small scale industry and services. Therefore, the resulting GDP statistics were not only arguably less reliable than before, but were also difficult to corroborate with consistent past time series. Given these arguments, it is clear that China’s GDP data needs to be dealt with in a pragmatic manner. Therefore, this thesis will use two different estimates and measures of output and the output gap. Details of this can be found in Appendix B (page 134).

2.3.3 Monetary and Exchange Rate Policy

Monetary Policy and the PBOC

The People’s Bank of China (PBOC) began functioning solely as a central bank in 1984. Prior to this, the PBOC had functioned also as a commercial bank. Its power in implementing monetary policy was strengthened by The Law of the People's Republic of China on the People's Bank of China passed by the Third Plenum of the Eighth National People’s Congress in 1995 which legally confirmed the PBOC's central bank status.

The objective of monetary policy in China as set by the Law of the People’s Bank of China is “......to maintain the stability of the value of the currency and thereby promote economic growth”.

While this is similar to the objectives of most advanced central banks, the PBOC use a variety of different monetary policy tools to achieve their goals. Compared to the single policy lending instruments often used by central banks in advanced economies, the PBOC has


A more detailed history of the development of the PBOC is given in Chapter 5 (see pages 92-94)

Speech by Mr Xiang Junbo, Deputy Governor of the People’s Bank of China, at the inauguration ceremony of the People’s Bank of China Shanghai Head Office, Shanghai, 10 August 2005

made use of a broad range of market oriented tools over the last two decades. It performs “window guidance”, sets lending quotas to pressure banks into restricting or expanding their credit, uses treasury bills issuance, as well as bank deposits and interest rates all to regulate money supply. Although interest rate liberalisation is on the agenda of the current five-year financial plan, the PBOC has yet to relax its grip on bank interest rates or the Reserve Requirement Ratio (RRR). Green (2004) has argued that China’s monetary policy tools are not yet as effective as they need to be to enable the PBOC to run an effective monetary authority. This can be attributed to the fact that market based monetary policy tools, such as the interest rate and reserve requirements, are often found to be unimportant in China relative to more blunt credit policies such as window guidance. In fact, market based monetary policy instruments were generally considered inadequate at influencing the Chinese economy throughout the 1980’s and 1990’s (Fernald et al 2014). Qin et al (2005) attribute this to a slower pace of reforms in the banking and financial sector relative to the rest of the economy. Instead, Chinese policy makers seeking to control cyclical fluctuations relied on more direct credit policies such as “telling banks when and who to lend”. Chen et al (2011), Fukumota et al (2010) and Fernald et al (2014) argue that these unconventional monetary policy tools, have begun or will begin to diminish as financial markets become less distorted. In fact in the latter, the authors find that the PBOC’s monetary policy transmission channel has become similar to those in advanced economies. These developments have been supported by continuous reform in the banking sector as well as an increase in the amount of independence and the ever evolving authority and autonomy given to the PBOC. Du (2003), Naughton (2007) and Mehrotra & Sanchez Feng (2010) have all argued that the PBOC have shown the ability to conduct largely independent monetary policy, similar to that carried out by monetary authorities in advanced economies. Chiu & Lewis (2006) also make the very valid point that by Chinese institutional standards, the PBOC have a great deal of independence and sovereignty in the conduct of monetary policy.

Despite evidence of a more market based monetary policy transmission channel and increased independence, the truth is that the PBOC still operate under the direct guidance and leadership of government. An Economist Intelligence Unit (EIU) Report published in 2014 warned that he PBOC’s independence in monetary policy will continue to be constrained as

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30 The different policy instruments, including these quantitative tools as well as the calculation of a monetary policy index based on a composite measure of all the tools used by the PBOC will be discussed at length in Chapters 4 and 5, see for example page 96.
31 Goodstadt (2014) provides an excellent overview of banking sector reform in China.
long as the State Council\textsuperscript{32} remains the final decision maker. Andreosso-O’Callaghan & Gottwald (2013) point out that while the PBOC may have consolidated its position as the most powerful organisation in the Chinese financial sector, it is still explicitly required to follow the leadership of the State Council. Bell & Feng (2013) also argue that the PBOC have often had to factor in the Chinese Communist Party (CCP) elites economic agenda of, what the authors call, “forced draft economic growth” when considering monetary policy actions. The PBOC is also constrained with regard to policy responses by the CCP’s external balance agenda and exchange rate regime. These factors have forced the PBOC to operate with an intermediate control system instead of fully embracing open market operations (OMO’s) as in most central banks. This “interference” of the state in macroeconomic adjustment was particularly evident during the global financial crisis in 2008. In November 2008, the State Council announced a ¥4trillion (around €580 billion) stimulus package. This included upgrading infrastructure, raising rural incomes via land reforms and other social projects such as affordable housing and environmental improvements. While this package was largely successful in softening the blow form the crisis, it served also to reverse many of the painstaking reforms and progressions that China had made in attempting to separate the state from macroeconomic activities, which usually fall under the remit of a central bank. Not only that, but the stimulus package was also at odds with the plans for a more consumption led growth model. Fabre (2013) for example argues that as the stimulus package is based on high levels of investment, the success of the stimulus is hinged on the assumption that new industrial capacities and infrastructure lead automatically to demand growth.

Given these arguments, it would seem that continued reform and liberalisation in the banking sector is needed and is particularly important in the context of China’s plan for a more balanced growth model. While the CCP have often pledged a commitment of complete reform, this has often been put on the long finger throughout the reform process. The PBOC in particular have long argued for a definite commitment to reforms that would encourage a culture in which firms made decisions based on market movements and the best interest of the shareholders with minimal intervention from the state (Goodstadt 2014).

\textsuperscript{32} The State Council is the highest administrative body in China and is responsible for the supervisor of all the main government institutions and agencies.
Exchange Rate Policy

China’s exchange rate policy has been a heavily debated topic in the macroeconomic literature over the past fifteen years\textsuperscript{33}. This topic was particularly contentious towards the end of the 2000’s in light of the global current account imbalances. A 2006 ECB Report\textsuperscript{34} stated that a significant part of savings growth in Asia reflected foreign exchange market interventions, associated with fixed or inflexible exchange rate regimes as for example in China. It has also been well documented, particularly among US commentators, that China has been running large current account surpluses over the past two decades (Figure 8). This has been concurrent with the tightly controlled exchange rate mentioned that prohibited the private sector from freely trading foreign assets (Chang et al 2014).

\textbf{FIGURE 8 – CHINA’S CURRENT ACCOUNT BALANCE OF PAYMENTS (BOP), 1980-2014}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure8.png}
\caption{China’s Current Account Balance of Payments (BOP), 1980-2014}
\end{figure}

\begin{itemize}
\item Current Account BOP (% Share of GDP)
\item Current Account BOP (in $ millions)
\end{itemize}

Source: China’s NBS and IMF International Financial Statistics (IFS)

Many commentators argue that China’s large current account surpluses reflect substantial undervaluation of its currency, the Renminbi (for example, Liu & Spiegel 2012, Bergsten 2010 and Goldstein & Lardy 2007).


Figure 9 plots the RMB/USD relationship and also the changes in China’s nominal effective exchange rate (NEER) since the reform period while Table 1 (page 35) gives an overview of China’s exchange rate regime since the reform period. From these representations we can see that China’s exchange rate was de facto pegged to the US dollar from 1994-2005. It is a well-known concept of monetary economics that the exchange rate of a country can be pegged as part of the domestic monetary policy approach and thereby used as a nominal anchor to create stable inflation expectations (Geiger 2008). Likewise, as a more short-term solution, a pegged exchange rate is often used for macroeconomic stability programs where runaway inflation needs to be halted through a strong and credible nominal anchor (Edwards 1992). Several studies have confirmed that the pegged exchange rate regime of the PBOC has been installed as a nominal anchor since 1994 (Prasad & Zhang 2012, Frankel 2006 and Goodfriend & Prasard 2006).

![Figure 9 - China’s Renminbi (RMB) Exchange Rate, 1980-2014](image)

**Source:** China’s National Bureau of Statistics (NBS) and IMF International Financial Statistics (IFS)

China’s managed exchange rate and resultant growth in foreign exchange reserves has the potential to pose major problems for China’s domestic economy. The exchange rate is controlled through foreign market interventions and has been an important ingredient in the PBOC’s monetary policy approach. The PBOC intervene in this manner by “mopping up”
foreign capital inflow by buying the foreign currency revenues of exports at the prevailing exchange rate.

While China’s undervalued currency on the back of its managed exchange rate is often credited with China’s export growth, the policy of intervening in the currency in this manner has resulted in the holding of foreign exchange (FX) reserves in an excessive amount (see Figure 10, page 36), which stood at $4.3 trillion as of 2015. This can jeopardise economic stability as it makes China’s balance sheet more vulnerable to external shocks. Among other things, the accumulation of foreign assets has an expansionary monetary effect and thus poses a challenge for domestic macroeconomic management (Zhang 2010). The process can also lead to increases in China’s domestic money supply which tends only to fan inflation. As a result, the PBOC will attempt to avoid inflation by reducing the money supply by selling an equivalent amount of its domestic currency bonds and other assets. This process is known as “sterilisation”. The problem with this practice is that the nominal yields on the PBOC’s foreign currency holdings are generally different from the nominal interest rates on domestic bonds. That means that sterilization can produce net gains or losses for the central bank, depending on how interest rates on foreign currency reserves compare with rates on domestic bonds. Thus, the PBOC faces a trade-off. It either takes a loss from sterilization or it risks increasing inflation by expanding the money supply. Importantly, this trade-off only happens under a closed capital account regime in which exporters can’t hold foreign assets (Liu & Spiegel 2012).

From this simple narrative analysis, it would therefore appear that China’s exchange rate policy, and in particular the huge build-up of reserves to maintain the value of the RMB, has several knock on effects for the Chinese economy. It has given China’s competitors (particularly the US, but also in the EU) ammunition in the argument that the Chinese government is a currency manipulator and conducts protectionist policy. Perhaps most crucially, in the context of China’s plans for rebalancing the economy to a more sustainable growth model, it distorts the money supply and may constrain adequate and appropriate monetary policy reaction.
TABLE 1 – CHINA’S EXCHANGE RATE REGIME

<table>
<thead>
<tr>
<th>Stage</th>
<th>Date</th>
<th>Characteristics of RMB Exchange Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of Reforms</td>
<td>1979-1984</td>
<td>Single Internal Settlement Rate (ISR) Regime - In 1981, the State Council introduced an ‘internal settlement rate’ which applied to all trade transactions conducted via government sanctioned ‘swap centers’ at which exporting firms were allowed to sell their retained foreign earnings. The rate was set at RMB2.80 per dollar. This was abolished in 1984 after international pressure.</td>
</tr>
<tr>
<td>First Era of Reform</td>
<td>1985-1993</td>
<td>Dual Exchange Rate Regime – Firstly the ISR was unified to an official rate in 1984 before being abolished in 1985. Instead, a dual system consisting of a foreign exchange swap market rate and an official rate. The swap rate was more flexible and market determined than the official rate. It became an increasingly important tool to offset the distortions caused by the overvalued official rate, thus helping to facilitate competitiveness in the export sector.</td>
</tr>
<tr>
<td>Second Era of Reform</td>
<td>1994-2005</td>
<td>Fixed “Dollar Peg” Exchange Rate Regime – In 1994, the dual exchange rate was abolished and the official exchange rate was pegged at around 8.3 per dollar. The foreign exchange surrender system was launched to facilitate this peg. This policy immediately impacted on China’s competitiveness with increases in exports of 32% and 23% in 1994 and 1995 respectively.</td>
</tr>
<tr>
<td>Current Period</td>
<td>2006-2015</td>
<td>Managed Float Exchange Rate Regime - The dollar peg was officially abandoned in July 2005 but in truth has appreciated only modestly since then (see Figure 9) The daily movement band has however been gradually moved from 0.3%, to 0.5% and the to 1.0% - mostly due to international pressure from China’s trading partners in the US and The EU</td>
</tr>
</tbody>
</table>

Notes: Details from Table 1 were sourced from PBOC website (2015) as well as international observers such as Cui (2015), Bell & Feng (2013) Goldstein and Lardy (2009), Yi (2008), Eichengreen (2006)
China’s Impossible Trinity

A fundamental contribution of the Mundell-Fleming framework is the impossible trinity, or “the Trilemma”. The impossibly trinity states that an economy may choose two but not all three of the policy goals of monetary policy independence, a fixed exchange rate and full capital mobility (Cheung & de Haan 2013). It is often represented in simple terms by the “Trilemma Triangle” (Figure 11, page 37). There is a general consensus that a fixed exchange rate has considerably restrained the PBOC from conducting independent monetary policy (Goodfriend & Prasad 2006). The simplest explanation of this theory in the Chinese case would be the following; if China adopts a fixed exchange rate and allows free capital flows then it will need to use monetary policy to maintain the foreign exchange rate and therefore will lose its monetary policy autonomy. Policymakers are thus obliged to choose between two of the three goals.
These restrictions can pose challenges for the effectiveness of China’s monetary policy. Under capital account restrictions, the PBOC intervenes by purchasing foreign-currency revenues from exporters at prevailing exchange rates, with the purchases financed by either issuing domestic currency or domestic bonds. The portion of foreign asset purchases financed by selling domestic bonds is said then to be “sterilized” (see page 34), in that it does not result in an expansion of money supply. Research on the topic of “the impossible trinity” for China has produced mixed results. Prasad (2009) argues that as it is constrained by a tightly managed exchange rate, monetary policy can at best play a very limited role for China in responding to economic shocks. Reade & Voltz (2010) find that through the maintenance of capital controls and the reliance on monetary instruments other than the interest rate, China has been able to exert relatively autonomous monetary policy. The authors however conclude with the inference that the PBOC’s policy mix is suboptimal, something they attribute to the dollar peg. Empirical evidence also suggests that capital controls can be circumvented and that they are not very effective in achieving a higher degree of monetary policy independence (Edwards 1999). Sheel (2014) makes the argument that many emerging market economies (EME’s) have managed to successfully navigate around the trilemma problem. This is done by adopting a separate instrument as part of a consistent policy framework to market the external financial cycle, instead of using a single policy instrument such as the interest rate to target both the external and domestic cycle. This allows for monetary policy autonomy, the author argues, as the interest rate is then free to deal with shocks to the business cycle without deviation from monetary policy targets. Goodfriend & Prasard (2007) argue that a flexible exchange rate regime is required by the PBOC to deliver
an effective monetary policy and further capital account liberalisation. The authors also suggest that while capital controls in China have insulated monetary policy to some extent, they are notoriously leaky and have become increasingly inefficient over time which adds to the argument for exchange rate liberalisation.

The analysis of Chinese monetary policy and exchange rate seems to suggest that the PBOC will face a further obstacle in the attempt to rebalance the economy’s growth model. This challenge involves pursuing independent monetary policy (to insure a smooth transition to this model) and limiting exchange rate flexibility (to maintain China’s international competitiveness) while all the time facing large and increasing amounts of international capital flows.

2.4 Summary

This chapter has provided a detailed background and economic framework to this thesis. It has discussed the key macroeconomic indicators of inflation, output and monetary/exchange rate policy, with an emphasis on the challenges faced as China attempts to shift its economy to a more balanced growth model. The preceding three empirical chapters will examine each of these key macroeconomic indicators individually.

Chapter 3 models inflation dynamics in China since 1987 using three different time series econometric models; (i) a standard OLS estimation (ii) a Phillips curve using the methodology proposed by Bai and Perron (1998), which allows for an unknown number of breaks at unknown dates, and (iii) a Markov switching model. The chapter attempts to determine if a Phillips curve framework could be used in inflation modelling by policy makers in China. Using the same econometric techniques, Chapter 4 estimates augmented versions of the Investment Saving (IS) curve for China in an attempt to examine the relationship between monetary policy, the credit market and the real economy. Finally, Chapter 5 incorporates the exchange rate into a monetary policy rule, while again using the three econometric techniques mentioned, to assess the impact that China’s controversial exchange rate policy had to macroeconomic stabilisation. Policy options and recommendations based on the results of these empirical chapters are then provided in Chapter 6.
Chapter 3. The Phillips Curve – Inflation Determination in China

3.1 Introduction

Given that China is now the world’s second largest economy and considering its overall importance in the global market, study in the area of Chinese inflation modelling is still a relatively under researched topic. Movement in price levels have huge significance both for the Chinese and international market. Besides the social unrest that rising prices often causes in China, inflation also endangers its status as the low-cost workshop of the world. Contractionary policies to fight inflation would cause the Chinese economy to falter and the effects would be felt worldwide. As a result of increased integration into the global economy and continuing domestic price liberalisation, prices in China have become increasingly market determined and therefore understanding the dynamics of inflation has become an important question both in theory and in practice, especially for central banks in the conduct of monetary & economic policy (Funke 2006).

The Chinese economy has changed drastically over the last three decades and this raises the question as to whether or not the dynamics of Chinese inflation have also changed over this time period and if so, what are the policy implications of such a change. Therefore, a model describing Chinese inflation needs to take account of these changes by allowing multiple structural breaks in the time series. This chapter will apply a standard OLS estimation, a multiple breakpoint model and a non-linear Markov switching methodology to a Phillips curve framework in order to fully capture any structural breaks, asymmetry and non-linearity associated with the structural changes in the Chinese economy during and after the reform period. By accounting for these characteristics, this chapter will examine if a trade-off between inflation and the output gap exists and if this relationship changed over time (multiple breakpoint model) or changed depending on the level of output versus potential output (Markov switching model). The estimations in this chapter will also examine if the reaction of supply shocks differs across different states or regimes. These empirical estimations will test the stability in the Phillips curve which would will aid policymakers in analysing inflation dynamics. Finally, the forecasting performance of the non-linear estimation is tested versus that of the standard linear model.
The chapter is structured as follows. Section 3.2 gives a review of the literature and outlines how this chapter adds to the research in the area. Section 3.3.1 presents the data used and gives a brief comment on China’s controversial exchange rate in the context of this chapter and Section 3.3.2 discusses the Phillips curve specification. Section 3.4.1 estimates the linear benchmark, Section 3.4.2 the multiple breakpoint model, Section 3.4.3 the Markov Switching model and Section 3.4.4 examines some dynamic simulations. Finally Section 3.5 concludes the main empirical findings of the chapter.

### 3.2 Literature Review

The initial discovery of the negative inflation-unemployment relationship by Phillips (1958) and popularized by Samuelson-Solow (1960), has been an important tool for monetary policy analysis over the past five decades. Phelps (1967) and Friedman (1968) criticised the original Phillips curve hypothesis, arguing that it was unreasonable to assume that nominal variables could affect real variables. This led to the expectations augmented Phillips curve which explained inflation by the unemployment gap and the expected inflation rate. Other approaches have often used the deviation of output from its potential i.e. the output gap Gordon (1997) and Sachs (1980).

The dynamics of inflation have changed substantially in most advanced economies over the past decades, leading to a renewal of interest in the Phillips curve in academic literature, particularly in the mid 1990’s. During this renewal, special interest was paid to the shape of the curve itself. Empirical evidence of the definitive shape of the Phillips curve for the US and other industrialised economies is, however, mixed. Akerlof el al (1996) and Debelle & Laxton (1996), among others, suggest that a convex Phillips curve is appropriate, Gordon (1997) argues in favour of a linear curve while Stiglitz (1997) even suggests evidence of a concave one. The growing branch of empirical and theoretical literature in this area usually proposes that inflation has been less responsive to fluctuations in output in recent years. Kuttner & Robinson (2010) argue that such a change can mean that a positive output gap would be less inflationary, but the cost of reducing inflation, once established, would be high. This issue has led to many studies in the area of non-linearity and asymmetry in the Phillips curve over the last twenty years, for example Demers (2003), Hamilton (2001) and Onder (2009). These authors used an array of different specifications including structural change models, time varying parameter models and regime switching models. The advantage
of using these techniques to examine inflation dynamics is that they can take into account the Lucas critique (1976)\textsuperscript{35}.

The majority of studies which have carried out research on Chinese inflation dynamics have used a standard OLS Phillips curve framework. Overall, the literature would suggest that such standard econometric models aren’t suitable for explaining macroeconomic dynamics in China. This is often attributed to the huge amount of structural change that the economy has experienced during the reform process. More generally, it has been suggested that the existence of structural breaks in inflation dynamics make linear models inappropriate tools for analysing inflation through time (Simon 1996).

Oppers (1997) uses a Phillips curve model over four different time cycles and finds that inflationary episodes in China have generally been associated with increases in aggregate demand, while Ha et al. (2003) demonstrate that the conventional Phillips curve fails to account adequately for its inflation dynamics mainly due to the difficulty in estimating the potential output of Mainland China, a problem which can be attributed to significant structural changes within its economy. Scheibe & Vines (2005) estimate a partially forward-looking Phillips curve as well as traditional backward-looking Phillips curves and discover that the output gap and the exchange rate play important roles in explaining inflation in China. Interestingly, this paper adjusted for structural changes in the economy where possible by including dummy variables for price liberalisation and estimating regressions using rolling sample windows. Gerlach & Peng (2006) found that a simple application of the Phillips curve does not fit Chinese data well, again citing the tremendous structural changes and policy shifts in China during the estimation period 1982-2006. They do however argue that a Phillips curve framework can provide an adequate fit for the Chinese data, provided the effect of structural changes on price formation are accounted for. In an OECD paper, Conway & Chalaux (2010) estimate a model based on that of Scheibe & Vines (2005) for the period 1988-2007. They also find that inflation reacts to the level of excess demand in the economy. Changes in the nominal effective exchange rate are also found to drive inflation in the estimation period, with currency appreciation working to bring down inflation. Their results come with the caveat that Chinese data is sensitive to the sample period and that

\textsuperscript{35} In this seminal paper, Lucas stated that ‘…given that the structure of an econometric model consists of optimal decision rules of economic agents and that optimal decision rules vary systematically with changes in the structure of the series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of the econometric model’.
structural change should be accounted for in the model. Zhang & Murasawa (2012) also argue that the standard Phillips curve does not seem to fit Chinese data well, which may reflect a data issue for China or the omission of certain important variables over different states in China. Instead they have estimated a new Phillips curve model using multivariate model-based gap measures for inflation and real output which provides a much better fit to their data.

While there has been very little research on China’s inflation dynamics using non-linear estimations, a small number of papers have emerged in the last few years including research by Zhang (2013), Zhang & Clovis (2010) & Wang (2010). There is however a definite gap in this area of the literature for examining the effect of structural breaks, asymmetry and non-linearity in the Chinese inflation process. This chapter will attempt to add to the literature on Chinese inflation dynamics by estimating a standard OLS estimation, a multiple break point model and a non-linear Markov switching Phillips curve. The latter two models will attempt to capture any non-linearity, breaks or asymmetry associated with the structural changes in the Chinese economy during and after the reform period. The multiple breakpoint model is useful as it can examine the changing relationship over time, before and after a particular point in time, for example a specific reform or policy. The Markov switching model on the other hand examines the changing relationship depending on the state characteristics for example high/low or stable/volatile. By doing so it may indicate instability in the Phillips curve which would help policymakers in analysing inflation dynamics in China.

3.3. Data & Phillips Curve Specification

3.3.1 Data

All three models estimated in this chapter were calculated using quarterly data from 1987Q1 to 2014Q3. The dependent variable for all models is the Chinese CPI inflation rate. Chapter 2 (Section 2.3.1, page 22) discusses China’s inflation data and some of the problems associated with its use in empirical estimations. We therefore use Chinese inflation data as available on the National Bureau of Statistics (NBS) as this is considered the most reliable source of Chinese data. Official Consumer Price Index (CPI) data is available from this source from 1987. For the excess demand variable, the output gap is used. The Chinese NBS
publish quarterly GDP data for China. This data is only available since 1992. Therefore, the output gap calculated by Oxford Economics Global Economic Databank\textsuperscript{36} is used in the estimations. There is a detailed description on both the choice and calculation of China’s output gap provided in Appendix B (page 134). As the estimations in this chapter use quarterly data, both the inflation rate and the level of real GDP are seasonally adjusted. Finally, for the supply shock, the log change in the nominal effective exchange rate is used. This quarterly data is available from the International Monetary Fund (IMF) International Financial Statistics (IFS). Figure 12 shows the plots of the three variables used in the estimations. The Phillips curve theory assumes that all variables used in the estimation are stationary\textsuperscript{37}. We can see from Table 2, which reports the results of the Augmented Dickey Fuller (ADF) Test, that all three variables pass the test for integration of order zero (I~ (0)).

<table>
<thead>
<tr>
<th>Variable</th>
<th>1 lag</th>
<th>2 lags</th>
<th>3 lags</th>
<th>4 lags</th>
<th>5 lags</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation Rate</td>
<td>-3.5***</td>
<td>-3.4**</td>
<td>-2.9**</td>
<td>-2.0</td>
<td>-3.1***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.02)</td>
<td>(0.01)</td>
<td>(0.11)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Output Gap</td>
<td>-2.1</td>
<td>-2.7**</td>
<td>-2.5*</td>
<td>-4.4***</td>
<td>-2.7**</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.02)</td>
<td>(0.05)</td>
<td>(0.00)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Change in NEER</td>
<td>-3.8***</td>
<td>-4.2***</td>
<td>-4.7***</td>
<td>-2.9**</td>
<td>-3.1***</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.02)</td>
<td>(0.02)</td>
</tr>
</tbody>
</table>

Notes: Rejection of the unit root hypothesis at the 10, 5 & 1% level is indicated with *, ** & ***. P-values are in parenthesis. Critical values for test with constant are -2.5, -2.8 & -3.4.

\textsuperscript{36} This output gap was measured using a production function approach. This variable is estimated as follows. “We construct our measure of potential output bottom up by looking at the inputs into the production function (labour supply, capital accumulation and the components of TFP). Subsequently, we benchmark this against actual GDP to period where we feel the economy was operating at potential to ensure the level of actual and potential GDP at those moment is equal and the output gap is zero” (Email received from Alessandro Theiss, China Economist, Oxford Economics 2014, available on request).

\textsuperscript{37} A time series is said to be stationary if there is no systematic change in mean (no trend), if there is no systematic change in variance and if strictly periodic variations have been removed.
A Note on the RMB Exchange Rate

The RMB exchange rate has received a great deal of attention both in the economic literature and in the media. Academics such as Koivu (2009) argue that the foundation of Chinese monetary policy has been a fixed exchange rate, while politicians and policy makers in the US claim that China intentionally suppresses the value of the Renminbi through massive market intervention to raise the competitiveness of its exports. In an emerging and transition economy where the interest rate channel is weak, the exchange rate channel often plays a significant role in propagating monetary shocks to output and prices.

Figure 12 – Inflation, Output Gap & Change in the NEER, 1987Q1-2014Q3

Because the authority adopted a defacto fixed exchange rate regime before July 2005 and still exerts influence on the value of the nominal exchange, it is of interest to examine whether keeping the value of domestic currency stable has helped to maintain price stability (Jiang &
Kim 2013). It is also important to examine if the exchange rate has affected inflation in China given that the PBOC has both price stability and exchange rate stability as its two policy goals. One potential difficulty in investigating this issue is that there is little variation in the nominal exchange rate against the U.S dollar before July 2005 because of the defacto fixed exchange rate regime. Nevertheless, the RMB vis-à-vis currencies of other trading partners fluctuated during this period, suggesting that it is still relevant to study the effect of exchange rate changes that include the fixed rate regime.

Given that the RMB has seemed to play an important role in the development of the Chinese economy, it is important to comment briefly on its development. Figure 12 shows changes in the nominal effective exchange rate (NEER) and Figure 13 the RMB/USD exchange rate. After a series of devaluations in the early 1990’s, Chinese officials fixed the RMB at 8.26 RMB/USD in 1994 and remained at this level until the dollar peg was abandoned in July 2005. From then until June 2008, China adopted a basket exchange rate regime which allowed for small and rigidly controlled appreciations of the RMB against the USD. The RMB appreciated by 20% over this time but returned to the dollar peg in the middle of 2008 due to the onset of the financial crisis – this time at 6.8 RMB/USD. This peg remained until June 2010 when it again began to appreciate and has modestly since then. China’s controversial exchange rate and its role in monetary policy is discussed in greater detail Chapter 2 (Section 2.3.3, page 32.)

![Figure 13 – Chinese Renminbi (¥)/US Dollar ($) & Developments, 1987Q1-2014Q3](image)

Source: IMF IFS & Author’s Research
3.3.2. Phillips Curve Specification

Gordon (2009) describes three Phillips curve equations for empirical testing – the Triangle Phillips Curve (TPC), the New Keynesian Phillips Curve (NKPC) and the Hybrid New Keynesian Phillips Curve (HNKPC). Before estimating any of the Phillips curve estimation we must first choose the specification which best suits Chinese inflation dynamics.

Triangle Phillips Curve (TPC)

One of the most popular specifications is the augmented Phillips curve which relates inflation to demand pressure and supply shocks. While conventionally the Phillips curve is specified as the relationship between unemployment and inflation, other economic activities are often used. This augmented Phillips curve is often estimated under the assumption of adapted expectations. This model based on inflation expectations, excess demand and a supply shock is often referred to as the Triangle Phillips Curve (TPC) of Gordon (1997) for the simple reason that it models inflation as a function of three explanatory variables. The uniqueness of the triangle Phillips curve is not only the inclusion of demand side pressures but also by a supply shock. As mentioned, inflation also indicates an inertia indicating that expectations are largely adaptive. Lagged inflation therefore remains an important determinant of inflation (Kapur 2012). The reduced form estimates of the Phillips curve, like those in Roberts (2006) usually take the following specification;

\[\pi_t = a + b(L)\pi_{t-1} + c\bar{y}_t + d z_t + e_t\] (4)

The variable \(\pi_t\) is the actual inflation, \(\pi_{t-1}\) is the lagged inflation rate, \(\bar{y}_t\) is the level of excess demand, \(z_t\) is the supply shocks, \(e_t\) is the disturbance term and \((L)\) is the lag operator. The lags of inflation (which in this case will = 2) are often interpreted as a proxy for inflation expectations and more generally to capture the observed persistence in inflation. According to Gordon (2011), lagged inflation allows the TPC to include a pure persistence effect due to fixed-duration wage and price contracts, and lags between changes in crude materials and final product prices. The level of excess demand is represented by the output gap, defined as real GDP minus potential GDP, so that a positive output gap represents excess demand. The theory suggests that if the economy is operating above its potential output level, inflation will

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38 A reduced from model is a type of econometric model that has been arranged algebraically so that each endogenous variable is on the left hand side on one equation and only predetermined variable (exogenous and lagged endogenous variables) are on the right hand side.
tend to rise and vice versa. Finally, the effects of the supply shock variable are examined. This variable, $z_t$, can include changes in the relative prices of food, energy, and imports as well as changes in the trend growth of productivity. The most common supply shock used in the Phillips literature is the change in oil prices. This may not be a suitable shock in the Chinese case mainly because of the regulatory structure of domestic oil prices which means changes in oil prices have a very small pass through effect on Chinese prices. In the preliminary estimations of this chapter, a Phillips curve was estimated with a variable for oil price but was not significant in any way. The proxy for the supply shock used is therefore log change in the nominal effective exchange rate (NEER). This is defined in foreign currency unit per Renminbi (RMB) such that an increase in this variable corresponds to an appreciation of the RMB. We therefore expect a negative sign for this variable in the estimation. Earlier versions of Gordon’s Phillips curve included changes in exchange rate in place of import prices. The nominal effective exchange rate is included in the Phillips curve model partly to capture inflation in imported goods and is appropriate given the huge amount of imports in the Chinese economy and will attempt to pick up changes in pass through inflation. This technique has been used in many Phillips curve studies for China, including Ha et al (2003), Scheibes & Vines (2005) and Conway & Chalaux (2010). Flood & Garber (1982) also show how changes in the exchange rate system will alter the degree of disturbances through a change in the expectations formed by rational agents in the asset market and consequently a change in the slope of the Short Run Aggregate Supply Curve (SRAS), an analogue of the Phillips curve. While the RMB was pegged to the USD without any movement from 1994-2005, the variable used, the NEER, varies throughout the estimation period. Therefore, the effect that these nominal appreciations and depreciations caused by changes in exchange rate policy or regime had on the inflation rate can be examined.

**The New Keynesian Phillips Curve (NKPC)**

Another standard model is the New Keynesian Phillips Curve (NKPC) which has been used widely in monetary policy literature. It was originally formulated by Roberts (1995) and has been used more recently as part of the New Keynesian Dynamic Stochastic General Equilibrium (DSGE) framework as in Clarida et al (1999). Derived from micro foundations,

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39 While gradual price liberalisation has promoted convergence between international and domestic energy prices (OECD 2013), the price of oil and petroleum products in China are still highly regulated by the government.
with optimal price setting by forward looking monopolistically competitive firms, this “purely forward” Phillips curve states that inflation depends upon expected future inflation as opposed to expected current inflation. The NKPC takes the following form:

$$\pi_t = aE\pi_{t+1} + b\bar{y}_t + e_t$$  \hspace{1cm} (5)$$

In this specification, $\bar{y}_t$ is the level of excess demand, $E\pi_{t+1}$ is expected future inflation and $e_t$ is the disturbance term. One drawback of with this model is that purely forward looking Phillips curves do not get much empirical support. As mentioned in the previous paragraphs, lagged inflation remains an important determinant of inflation and many studies have shown that a purely backward looking model is preferred by the data (Fuhrer 1997, Rudebusch & Svensson 1998, Linde 2001 and Roberts 2005). Purely forward looking models such as the NKPC on the other hand have performed poorly in empirical tests as they fail to capture inflation persistence observed in the data. Fuhrer et al (2009) argue that there is little evidence that a forward looking Phillips curve provides a better estimated than that of a standard looking one. Gordon (2009) also states that the triangle model outperforms the NKPC while Rudd & Whelan (2005) argue against the validity of the forward looking expectations.

**The Hybrid New Keynesian Phillips Curve (HNKPC)**

Considering these arguments Clarida et al (1999) attempted to distinguish between the two interpretations of the triangle Phillips curve and the New Keynesian Phillips curve by estimating a hybrid specification, known simply as the Hybrid New Keynesian Phillips Curve (HNKPC). Their estimations found that forward looking expectations were significantly larger than backward expectations and interpreted this result as implying that the New Keynesian curve with forward looking expectations provides a good approximation of the true inflation process.

$$\pi_t = a\pi_{t-1} + bE_t\pi_{t+1} + c\bar{y}_t + e_t$$  \hspace{1cm} (6)$$

While this so called Hybrid NKPC fits the data well in the above mentioned papers, Rudd & Whelan (2005) argue against the relevance of the forward term in this specification. While it would therefore appear that there is no real consensus regarding which of the two price adjustment schemes (backward or forward-looking), should be chosen, the conclusion of the Rudd & Whelan paper mentioned above however, give a clear warning against the use
of the new Keynesian Phillips curve, or hybrid variations that place a large weight on forward looking expectations for policy analysis.

3.4. Estimations

3.4.1 OLS Benchmark Estimation

It is important to choose the correct Phillips curve specification which is most suitable to be the linear benchmark for Chinese inflation. This decision needs to be economically and econometrically justified. It has been noted that the backward looking price setting is more prominent in emerging economies such as China. There are many possible reasons for this including a lack of credibility in the central banks or the adjustment of regulated price contracts which would ultimately cause a higher level of persistence (Gertler & Rogoff 2002). Higher inflation rates and inflation volatility in the late 1980’s into the early 1990’s (see Figure 2, page 21) may have affected the credibility of the PBOC during the reform period. For this reason alone, one would expect an important role for the backward looking component of the Phillips curve. Gordon (2011) also points out that there is no explicit treatment of the supply shock in the NKPC, instead these are suppressed in the error term. Given China’s huge amount of imports and its controversial exchange rate policy, the treatment of external supply shocks may be an important factor in modelling Chinese inflation. This point is reiterated by Kapur (2013) in a study of Indian inflation dynamics. He states that emerging economies such as India (and China) have more complex inflation dynamics than advanced economies in view of recurrent supply shocks.

Anecdotal evidence would therefore suggest that the TPC is the best option for the linear benchmark. It is also however very important to analyse what the data is telling us. Table 3 shows the estimations of the TPC, NKPC and the HNKPC. At first glance, it would appear that the TPC provides a fairly robust model for Chinese inflation dynamics. All of the coefficients have the correct sign and are statistically significant. The $R^2$, which is reported as 0.96 is also very high. The sum of the significant autoregressive coefficients $\pi_{t-1}$ and $\pi_{t-2}$, is high at 0.90, which indicates that inflation is very persistent in China over the estimation period$^{40}$. The demand shock coefficient, represented by the deviation of output from its natural level, is 0.11 which is correctly signed and significant, albeit at the 10% level. This would suggest that deviations in the output gap played a role in inflation.

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$^{40}$ All significant lags of inflation were included in the estimation.
dynamics in China over the last twenty-five years. The supply shock, expressed as changes in the NEER, while small in magnitude, -0.05, is correctly signed and highly significant. As the NEER is defined in foreign currency unit per Renminbi (RMB), an increase in this variable corresponds to an appreciation of the RMB. Theory states that an appreciation helps to reduce inflation and so we have the expected minus sign. As there are lags of the dependent variable in the estimation, the Durbin Watson test statistic is not an appropriate test for the presence of autocorrelation. Therefore, the Lagrange Multiplier (LM) test for serial correlation is applied to the model. The LM test suggests that residuals are free of correlation for the linear benchmark. The LM test also confirms satisfaction with regard to heteroscedasticity effects. Note that the standard errors in the TPC estimation are adjusted using the parametric heteroscedastic autocorrelation consistent (HAC) Newey & West (1987).

**Table 3: Phillips Curve Estimation - OLS Estimation (1988Q1-2014Q3)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Triangle (4)</th>
<th>New Keynesian (5)</th>
<th>Hybrid New Keynesian (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable: China’s CPI Inflation Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.01***</td>
<td>0.01***</td>
<td>-0.01</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td>(0.02)</td>
<td>(0.14)</td>
</tr>
<tr>
<td>Inflation Lag</td>
<td>0.90***</td>
<td></td>
<td>0.50***</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td></td>
<td>(0.09)</td>
</tr>
<tr>
<td>Inflation Expectation</td>
<td></td>
<td>0.92***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.04)</td>
<td></td>
</tr>
<tr>
<td>Excess Demand</td>
<td>0.11*</td>
<td>0.29***</td>
<td>0.02</td>
</tr>
<tr>
<td>(Output Gap)</td>
<td>(0.06)</td>
<td>(0.11)</td>
<td>(0.22)</td>
</tr>
<tr>
<td>Supply Shock</td>
<td>-0.05***</td>
<td></td>
<td>-0.01</td>
</tr>
<tr>
<td>(NEER)</td>
<td>(0.01)</td>
<td></td>
<td>(0.36)</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.96</td>
<td>0.92</td>
<td>0.99</td>
</tr>
<tr>
<td>LM F-Stat</td>
<td>1.4</td>
<td></td>
<td>2.7*</td>
</tr>
<tr>
<td>DW Stat</td>
<td></td>
<td></td>
<td>0.74</td>
</tr>
<tr>
<td>SupF Stat</td>
<td>38.5***</td>
<td>20.1***</td>
<td>19.96***</td>
</tr>
</tbody>
</table>

The Inflation Lag (\(\pi_{t-1}\) in Equation 4) includes all significant lags of the dependent variable which was = 2. The 0.90 therefore represents the sum of the autoregressive coefficients ***, ** and * denotes significance at the 1, 5 and 10% respectively. HAC standard errors for the TPC are in parenthesis.
The forward looking NKPC also seems at first glance to provide a good fit with a significant value for both expected inflation and the output gap. The Durbin Watson (DW) statistic however shows evidence of autocorrelation in the residuals. With the Hybrid specification, while both the forward and backward looking variables are significant, the excess demand coefficient represented by the output gap is not significant. This model also fails to pass the diagnostic tests for heteroscedasticity and autocorrelation. The results of the linear therefore estimations confirm that the backward looking TPC is the best linear benchmark. However it is also important to note that all three Phillips curve specifications, including the TPC, failed the test for parameter stability. This test was carried out by applying the Quandt/Andrews $SupF$ statistic\textsuperscript{41}. The stability assumption is strongly rejected by this $SupF$ test for the linear model which suggests that the Chinese Phillips curve is not generated by a stable relationship and that some kind of structural break is present. The structural breaks test across all estimations relates the breakpoint to 1994-95. In the next section we will also see that there is an important breakpoint in 1994 which may have changed the nature of inflation dynamics. The most obvious explanation of a breakpoint in this period is the adoption of the dollar peg (\textit{see Section 2.3.3}).

The thesis has already mentioned that since 1994, there has been a marked decrease in both the rate and volatility of inflation. McKinnon (2007) argues that the fixed exchange rate anchored not only China’s inflation but also its macro economy more generally. The author suggest that the adoption of this pegged regime helped to end China’s “roller coaster ride” in domestic inflation characteristic of the 1980’s and early 1990’s. This was not the only major policy change or reform in this period however. There were also major reforms in the area of fiscal and banking policy. A main component of this was the disconnect of monetary policy from government fiscal transfers. Prior to these reforms, credit was often extended in excess of pre-planned budgets at the local government level (Girardin & Ping 1997). The PBOC would then ultimately be forced to fill the gap and contribute to the money supply thus causing inflationary pressure. During these reforms, policy banks were also created (\textit{see Chapter 5, page 93}) removing these requirements which meant that the PBOC

\textsuperscript{41}This is a test for parameter stability at each of the different points of a time series. Pioneered by Quandt (1960) and developed by Andrews (1993), it tests for one or more structural break points in the sample of a specific regression equation. It is prudent to test for structural breaks in this manner when the time series in question has experienced shocks and abrupt policy changes like those experienced by the Chinese economy. The null hypothesis being that there are no structural breaks. More details on this test can be found in \textit{Appendix A, page 129}. 

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could focus more attention on rebalancing the macro economy. This may also have changed
the dynamics of Chinese inflation.

From the overall results of the linear benchmark model, it is obvious that the presence
of structural breaks make a standard linear Phillips curve inappropriate for an accurate
analysis of Chinese inflation dynamics. Therefore, other econometric techniques need to be
applied to the Chinese Phillips curve for a more robust explanation of the inflation process.

### 3.4.2 Multiple Breakpoint Model

The standard linear regression model assumes that the parameters of the model do not vary
across observations. Despite this assumption, structural change, the changing of parameters
at dates in the sample periods, plays an empirically relevant role in applied time series
analysis\(^{42}\). This is particularly true of economies that have experience reform and
institutional change such as China. Therefore, a linear regression model that is subject to
structural change is estimated. There has been a large volume of work targeted at developing
testing and estimating methodologies for regression models which allow for change. Hansen
(2001) offers a useful overview of the literature and a more detailed description of this
technique can also be found in *Appendix A* (page 129).

The seminal work of Chow (1960) and Quandt (1960) developed the testing
procedure for structural changes in a time series at a single specified (hence known) break
date. This work was closely followed by Andrews (1993), Andrews & Ploberger (1994),
develop methods that allow for estimation and testing of structural change at unknown break
dates. Andrews *et al.* (1996) consider multiple structural changes but require a known
variance. Liu *et al.* (1997) also test for multiple unknown change points but consider only the
pure structural change case where all parameters are subject to shifts. Therefore, the
procedure hypothesised by Bai-Perron (1998, 2003) is adopted. An important feature of this
test is that it allows us to test for multiple breaks at unknown dates. It is well documented that
the effects of financial liberalisation and economic reform are difficult to model using
standard OLS regressions, often due to the structural breaks that such events can cause in the
time series (Blangiewicz & Charemza 1999). The Bai–Perron (BP) procedure is useful in

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\(^{42}\) Details of the multiple breakpoint regression model were sourced from Bai (1997), Bai & Perron (1998),
such a case as it allows the user to find the number of breaks implied by the data, as well as estimating the timing of the breaks and the parameters of the processes between breaks. The methodology can be used to estimate multiple structural changes in a linear model estimated by least squares. It treats the number of breakpoints and their locations as unknown. Consider the below Phillips curve model with \( m \) breaks:

\[
\pi_t = a_1 + b_1 \pi_{t-1} + c_1 \bar{y}_t + d_1 z_t + e_t, \quad t = 1, \ldots, T_1 \quad (7)
\]

\[
\vdots
\]

\[
\pi_t = a_m + b_m \pi_{t-1} + c_m \bar{y}_t + d_m z_t + e_t \quad t = T_{m+1}, \ldots, T \quad (8)
\]

Where the breakpoints \((T_1, \ldots, T_{m+1})\) are treated as unknown. The Bai-Perron estimation is based upon least square estimates of \( a_i, b_i, c_i, \) \& \( d_i \) are obtained by minimizing the sum of squared residuals

\[
\sum_{i=1}^{m+1} \sum_{t=T_i+1}^{T_i} (\pi_t - a_i - b_i \pi_{t-1} - c_i \bar{y}_t - d_i z_t)^2 \quad (9)
\]

To determine the number of breakpoints the “sequential process” suggested by Bai-Perron is used. The first step is to test the null hypothesis that there is \( l = 0 \) structural breaks using the SupF test. If the null hypothesis of \( l \) breaks is rejected in favour of the \( l + 1 \) breaks alternative, the test is applied to each sub-sample and so on, until rejection fails.

### Table 4 - Phillips Curve with Multiple Breakpoints (1987Q3-2014Q3)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Period 1</th>
<th>Period 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variable: China’s CPI Inflation Rate. Break date 1994Q1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.06*** (0.02)</td>
<td>0.01*** (0.01)</td>
</tr>
<tr>
<td>Inflation Lag (-1)</td>
<td>1.37*** (0.04)</td>
<td>0.98*** (0.15)</td>
</tr>
<tr>
<td>Inflation Lag (-2)</td>
<td>-0.79*** (0.10)</td>
<td>-0.19*** (0.13)</td>
</tr>
<tr>
<td>Excess Demand (Output Gap)</td>
<td>0.68*** (0.17)</td>
<td>0.23** (0.09)</td>
</tr>
<tr>
<td>Supply Shock (NEER)</td>
<td>0.05 (0.04)</td>
<td>-0.11*** (0.02)</td>
</tr>
</tbody>
</table>

***, ** and * denotes significance at the 1, 5 and 10% respectively. HAC standard errors are in parenthesis.

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Table 4 illustrates the results of the multiple breakpoint model. The results indicate that the Phillips curve relationship (between inflation and the output gap) held across period’s 1987Q3-1994Q1 and 1994Q2-2014Q3. The regression results would also suggest that inflation persistence was relatively high across both Period 1 and Period 2 and actually increased over time. Inflation persistence is defined as the tendency for price shocks to push the inflation rate away from its steady state—including an inflation target—for a prolonged period. The increase in inflation persistence has important policy implications for the PBOC. High inflation persistence renders the PBOC monetary policy less effective as it will delay the response of inflation to various shocks. It will also prolong any inflation and output effects of monetary policy actions. It is a well acknowledged argument that high inflation persistence contributes to make the life of central bankers more difficult. What may be surprising is that the persistence increased at a time when further reforms were introduced in the banking sector which would have actually given the PBOC greater power and autonomy.

The reaction of excess demand (deviations of output from its natural level) is both correctly signed and significant across both periods. This relationship was much stronger in Period 1 than in Period 2. To get a more detailed analysis of this relationship we can analyse the summary statistics in Appendix C (page 139). From these statistics we can calculate the effect of a 1% standard deviation (S.D.) in the independent variables to the inflation rate. In Period 1, a 1% S.D. of output from its natural level results in 0.23% change in the inflation rate. In Period 2 the effect is much smaller, with the same change in output leading to just a 0.07% change in inflation. This suggests that the inflation/output relationship has weakened since 1994 and that there has been a flattening of the Phillips curve relationship in China. The flattening of the Chinese Phillips curve can be seen graphically in Figure 14 which plots the inflation/output relationship across both periods. This flattening of the Phillips curve has important policy implications. In one respect, it makes the PBOC’s task a little easier as they do not have to be overly concerned between temporary imbalances.

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43 As in our linear estimation, standard errors are calculated on the assumption that the residuals are heteroscedastic across regimes i.e. HAC standard errors. This will also be applied to the linear and breakpoint models of Chapter 3 & 4.
44 For the remainder of this chapter, I will refer to 1988Q1-1994Q1 as Period 1 and 1994Q2-2014Q3 as Period 2.
45 We can interpret the movements of one variable on another by examining their standard deviations i.e. how many standard deviations the dependent variable increases when the independent variable increases. This technique is used throughout the thesis and becomes particularly useful in Chapters 3 and 4.
46 The standard deviations (S.D.) are calculated by multiplying the coefficient given for the independent variable by the S.D. of that variable divided by the standard deviation of the inflation. The calculation for example using the output gap in Period 1 is 0.68 * (2.4%/7.2%) = 0.23%
between demand and supply. However, it will also make responding to any inflation shocks more difficult as the PBOC will need to adjust its monetary policy and reduce output considerably more to bring inflation back to the target level.

Finally, the effect of the supply shock, which is represented by a change in the NEER, can be examined. In Period 1, the NEER is incorrectly signed and not significant indicating that the exchange rate played no role in inflation prior to 1994. In Period 2, the NEER has both the correct negative sign and is also highly significant with a coefficient of -0.11. This suggests that changes in the exchange rate had a significant effect on the inflation rate during the 1994Q2-2014Q3. The summary statistics in Appendix C indicate that this period, Period 2, can be characterised as a relatively low and stable period of Chinese inflation. The results may indicate that the PBOC’s exchange rate policy was a factor in the low and stable inflation period. It is important to note that the increase in the significance of the NEER corresponds to a diminished effect of output on inflation. This suggests that China’s exchange rate regime in this period, Period 2, may have played a role in the breakdown of the inflation/output relationship.

**FIGURE 14 – INFLATION/OUTPUT GAP RELATIONSHIP PERIOD 1 & PERIOD 2**

(a) Period 1 1987Q3-1994Q1  
(b) Period 2 1994Q2-2014Q3

*Source: Author’s calculations using simple linear estimation*
Another very interesting finding from both the results of the estimation and the plot of the inflation/output relationship is that that the Chinese Phillips curve would appear to be concave in shape\(^{47}\). Figure 15 gives a very basic representation of a concave Phillips curve. The idea of the concave Phillips curve was proposed by Stiglitz (1997), Eisner (1997) and further developed by Filardo (1998). A concave Phillips curve is an upward sloping curve that flattens as output rises above its natural or potential level. The curve is steeper at levels of output below potential. A concave Phillips curve points to the declining sensitivity of inflation to the strength of the economy. While a concave Phillips curve may seem like an unconventional idea, Stiglitz (1997) argues that it can often exist in an economy where firms are not purely or perfectly competitive. This would seem to fit the Chinese case when you consider such things as the dominance of large state owned enterprises, state monopolies in sectors such as utilities, telecommunications, transport and even asset monopoly\(^{48}\) as well as regulated markets for certain sectors, for example energy prices. As firms like this have pricing power and thus the ability and desire to influence their market share, they will be more reluctant to raise prices than to lower them. In this case, firms will respond to an increase in economic activity with more muted price changes and larger output changes than to a similar decrease in economic activity (Filardo 1998). With a concave Phillips curve, the PBOC monetary policy will be more effective during periods of expansion rather than recession. The PBOC would need to take significantly more action to reduce inflation when the level of economic activity is high i.e. the output cost of reducing inflation is higher during periods of higher output than periods with lower output. On the other hand, the risks of taking more aggressive policy measures in order to increase output might be lower than if the curve were both convex and linear.

As the shape of a Phillips curve therefore determines the cost of disinflation, it has important implications for the PBOC’s monetary policy. It means that the effectiveness of China’s monetary policy actions will depend on whether the economy is operating below

\(^{47}\) This can be deduced by examining both the results in Table 4 and the summary statistics in Appendix C. For example, in Period 1, the inflation rate is sensitive to deviations in the output gap. The summary statistics show that the mean of the output gap in Period 1 was \(-2.7\%\) (i.e. below potential). In Period 2, deviations have a much smaller effect on inflation. The mean of the output gap in this period is \(0.01\%\) (operating around potential).

\(^{48}\) The assets monopoly is a key feature of the Chinese system. Although in theory the SOEs are publicly owned, citizens are not the shareholders. Instead, appointed government agents hold a monopoly over these assets. This phenomenon leads to inefficiencies, a lack of innovation, inequitable distribution, corruption, and imbalances in the economic structure (Duan & Saich 2014)
potential, around potential or above potential output. We will also see an extension of this idea in Chapter 4.

![Figure 15 - Representation of a Concave Phillips Curve](source: Filardo (1998) & Author’s Research)

### 3.4.3 Markov Switching Model

While the estimations in Section 3.4.2 provides a better insight into the inflation process in China than the standard linear model, the multiple breakpoint regression is limited in that it does not allow us to switch between different regimes. Even a simple graphical analysis of Figure 2 and 12 (pages 21 and 44) would suggest that there may have been a switch in inflation dynamics with both high inflation and periods of deflation occurring during the estimation. Therefore, in the pursuit of robustness, this section evaluates the Chinese inflation process through a Markov switching (MS) model. As mentioned in Appendix A (page 129) the MS model will not just characterise different characteristics over time as the breakpoint model, but will characterise relationships depending on the state of the economy and the stage of the business cycle.

Many economic time series occasionally exhibit dramatic breaks in their behaviour, associated with events such as financial crises or abrupt changes in government policy (Hamilton 2005). The Chinese economy in particular has experienced tremendous structural changes in recent decades, associated with the gradual opening of the economy. Prices have been liberalised, trade has increased extensively, companies have been privatised and the economy has been transformed from one that was centrally planned prior to 1978 to market economy (Brandt & Rawski 2008). It has also experienced several economic shocks some of
which were related to policy measures to liberalise the economy (Gerlach & Peng 2006).

The breaks in the time series associated with these events make linear models inappropriate for analysing macroeconomic variables over time. To fully capture non-linearity’s, a model of Chinese inflation dynamics using the Markov switching (MS) model of Hamilton (1990)<sup>49</sup> is estimated. The MS model is so called because the switching mechanism is controlled by an unobserved state variable $s_t$ that follows a first order Markov chain process. An interesting feature of the MS model is that the filtered probabilities can be interpreted as the agent’s belief that the economy is in one of the possible states that describe the economy. It is also a very useful technique as the unobserved or latent state variable can be linked (or at least possibly linked) to an observable event, policy or characteristic.

By fitting the linear Phillips curve equation to the MS framework<sup>50</sup>, we get:

$$\pi_t = a_{st} + b_{st}\pi_{t-1} + cY_t + dz_{st} + e_t$$ (10)

Where $e_t \sim i.i.d. N (0, \sigma^2_{e,st})$ and with unobserved state $s_t$, which is assumed to follow a Markov chain of order 1 with transition probabilities $p_{ij}$. The transition probability $p_{ij}$ gives the probability that state $i$ will be followed by state $j$.

$$P_{ij} = \Pr[ s_t = j \mid s_{t-1} = i ], \quad \sum_{i=1}^{M} p_{ij} = 1, \quad \forall i, j = 1, \ldots, M$$ (11)

This is often then written in an $(M \times M)$ matrix $P$, called a transition matrix:

$$P = \begin{bmatrix} p_{11} & p_{21} & \cdots & p_{M1} \\ p_{12} & p_{22} & \cdots & p_{M2} \\ \vdots & \vdots & \ddots & \vdots \\ p_{1M} & p_{2M} & \cdots & p_{MM} \end{bmatrix}$$ (12)

The row $i$, column $j$ element of $P$ is the transition probability $p_{ij}$. To demonstrate, in the above matrix (12), the row 2 column 1 element gives the probability that State 1 will be followed by State 2. Let us for example, say that at time $t$, the state of the economy $s_t$ is classified as either high inflation in $s_t = 1$ or low inflation in $s_t = 2$. In our estimation, let us assume that the model gives us a probability of 95% of being $p_{11}$ and 5% of being $p_{21}$. What these values tell us is that if the economy is in a state of low inflation in the previous period,

<sup>49</sup> For a detailed account of the Markov Switching procedure see Hamilton (1994). There is also a more detailed description in Appendix A (page 129).

<sup>50</sup> In the interest of robustness estimations were carried out using both the Markov Switching estimation function on Eviews 8 and the MS_Regress_Fit package developed by Perlin (2012). The results were very similar.
it tends to stay in a low inflation state with a very high probability of 95%. On the other hand, the probability of being in a low inflation state in the previous period and switching to a high inflation state is low at just 5%.

The estimation of the model depends on maximum likelihood. The maximization of likelihood function of the model requires an iterative estimation technique to obtain estimates of the parameters of the model and the transition probabilities. With the parameters identified, it is then possible to estimate the probability that the variable of interest, in this case Chinese inflation, is following a particular regime. It is also possible to derive the smoothed state probabilities which indicate the probability of being in a particular regime or state. Before estimating the Markov switching Phillips curve, the number of states or regimes to be included in the model must be chosen. As there are often relatively few transitions among states, it is difficult to estimate strictly exogenous explanatory variables accurately. For this reason, most applications assume only two or three states (Hamilton 2005). Tests for both a two-state and three-state Markov switching Phillips curve were carried out. The three-state was rejected against the two states since the data points are detected only in the first and second states. Table 5 reports the estimation of Equation 10 – the MS Phillips curve and Figure 16 (page 61) plots the states estimated by the model along with a plot of the annual CPI inflation rate and Appendix provides summary statistics for both state.

The results of the Markov switching Phillips curve provide a new perspective on inflation dynamics in China. From Figure 16 we can see that Chinese inflation switches back and forth frequently from State 1 to State 2. Overall, the state properties indicate that State 1 lasts slightly longer than State 2 in the selected time period. The typical duration of each state is 12 quarters for State 1 and 9 quarters for State 2. The coefficients for the lag of inflation show that inflation persistence is high in both State 1 and State 2. The high inflation persistence across the entire sample is consistent with the paper’s previous estimations which may point to the lack of credibility and transparency of the PBOC. It is also important to note that inflation persistence is particularly high in State 2 which is often characterised by decreasing inflation (see Figure 16). This suggests that Chinese markets are not confident in the PBOC controlling inflation even when inflation is decreasing. The output gap is highly significant and correctly signed in State 1 but not statistically significant in State 2. Using the

\[ \frac{1}{1 - P_{it}} \]

51 For more details on these technique and the maximum likelihood see Hamilton (1994) and Kim & Nelson (1999)
52 This is calculated by \[ \frac{1}{1 - P_{it}} \]
coefficients in Table 5 and summary statistics in Appendix C, it was calculated that a 1% S.D. in the output gap in State 1 will have a 0.11% S.D. effect on the inflation rate. There is no significant relationship between inflation/output in State 2 i.e. a flat Phillips curve.

<table>
<thead>
<tr>
<th>Variable</th>
<th>State 1</th>
<th>State 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variable: China’s CPI Inflation Rate.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.01***</td>
<td>0.03***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Inflation Lag (-1)</td>
<td>1.02***</td>
<td>1.65***</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>Inflation Lag (-2)</td>
<td>-0.29***</td>
<td>-0.69***</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
<td>(0.05)</td>
</tr>
<tr>
<td>Excess Demand (Output Gap)</td>
<td>0.38***</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>Supply Shock (NEER)</td>
<td>-0.02***</td>
<td>-0.08**</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>( p_{11} )</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>( p_{12} )</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>( p_{21} )</td>
<td></td>
<td>0.11</td>
</tr>
<tr>
<td>( p_{22} )</td>
<td></td>
<td>0.88</td>
</tr>
<tr>
<td>Duration of State</td>
<td>11.9 quarters</td>
<td>8.8 quarters</td>
</tr>
</tbody>
</table>

Notes: ***, ** and * denotes significance at the 1, 5 and 10% respectively. Standard errors are in parenthesis.

The supply shock variable \( z_t \), which is represented by changes in the nominal effective exchange rate, is found to be significant across both states of the model. The sign of the coefficients are, as expected, negative across both states as the exchange rate index increases with an appreciation of the RMB. This implies that if the Chinese exchange rate appreciates over time, it will have a negative influence on the inflation rate as China’s imported goods will be cheaper. The reaction of inflation to changes in the NEER increases as the economy moves from State 1 to State 2. A 1% S.D. in the NEER in State 1 and 2 leads to a 0.01% and 0.18% S.D. in the inflation rate respectively.
While the MS model provides a different perspective on China’s inflation dynamics, the results of these estimations are actually complementary to those of the multiple breakpoint model. The MS estimations find a strong inflation/output relationship in State 1, when output was operating below its natural or potential level. In State 2 on the other hand, there is no significant relationship between inflation and output. State 2 is defined as a state when output is operating on or above its natural level. This reiterates the findings of the multiple breakpoint model which also found a decreasing sensitivity of inflation to the strength of the economy.

This finding has important policy implications for Chinese policymakers. It implies that changes in output through monetary policy responses will have more effect on inflation when the economy has a negative output gap and is operating below its potential or natural level. The MS estimations, again similar to the multiple breakpoint calculations, find that an increase in the significance of the exchange rate as the economy switches from State 1 to State 2, corresponds to a decrease in the sensitivity or the reaction of inflation to deviations in the level of output. One possible explanation for this is that China’s exchange rate policy constraining independent monetary policy. This will be discussed at length in Chapters 4 and 5 of this thesis.

Summary statistics in Appendix C calculate the mean of the output gap to be -2.1% in State 2 and 0.02% in State 1.

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53 Summary statistics in Appendix C calculate the mean of the output gap to be -2.1% in State 2 and 0.02% in State 1.
3.4.4 Dynamic Forecasts & Simulations

We have seen in the previous sections that the Markov switching Phillips curve seems to better explain the dynamics of the Chinese inflation process. It is also important to analyse if the same can be said about its forecasting performance. This section presents a dynamic forecasts based on the linear triangle Phillips curve, *Equation 4*, and the Markov Switching Phillips curve, *Equation 10*. This will allow us to examine if the MS Philips curve specification is more appropriate than the linear model in terms of forecasting and simulation performance. As mentioned in the introduction of this chapter, linear models of inflation have often been criticised for their poor forecasting performance. On the other hand, the use of Markov switching models often lead to compelling results, for example the identification of business cycles, at least in terms of in sample analysis. *Figure 6* illustrates the dynamic simulations of the both the linear Phillips curve and the Markov switching curve. While there is not a huge difference between the two, the illustrations clearly indicate the superior forecasting capabilities of the Markov switching Phillips curve. This can be confirmed from the respective root-mean-squared errors (RMSEs) of 0.05 and 0.04 for *Equation 4* and *Equation 10* respectively. The results of these estimations indicate that the Markov switching Phillips curve, if only marginally, outperforms the simple linear model in forecasting the magnitude and direction of changes in the price level. This reiterates the point made earlier about the importance to the PBOC of addressing structural breaks, asymmetries and non-linearity’s in the inflation process when making monetary policy decisions.

*Figure 17 – Dynamic Forecasts & Simulations*

Source: Author’s Estimations
3.5. Conclusion

This chapter models inflation dynamics in China since 1987 using three different time series econometric models. The results of the standard OLS benchmark estimation revealed that the Chinese Phillips curve is not generated by a stable linear relationship and that some kinds of structural breaks and non-linearity is present. This implies standard OLS Phillips curve for China would provide misleading information with regard to inflation dynamics and would ultimately lead to an inappropriate policy stance. The chapter then attempted to establish if a multiple breakpoint model and Markov switching model could be used to provide a better understanding of the inflation process in China. The results of the multiple breakpoint model and the Markov switching model were very similar and seem to provide a more robust analysis of the inflation process in China.

The multiple breakpoint estimation found a breakpoint at 1994Q1 after which both the persistence of inflation and the effect of changes in the exchange rate increased. What was perhaps most interesting is that the estimations suggest that the Chinese inflation/output relationship in concave. A concave Phillips curve is an upward sloping curve that flattens as output rises above its natural or potential level. The curve is steeper at levels of output below potential. A concave Phillips curve points to the declining sensitivity of inflation to the strength of the economy.

The results of the Markov switching Phillips curve estimations are concurrent with the estimations of the breakpoint model. First, it reveals that inflation in China is characterised by two states – State 1 & State 2. Consistent with the multiple breakpoint model, the MS model indicates that the Chinese Phillips curve appears to have a concave slope, reflecting the declining sensitivity of inflation to the strength of the economy. It suggests that inflation is more responsive to output when the economy is operating below the potential level i.e. negative output gap. The estimations also suggest that a Markov switching Phillips curve provides a better framework for forecasting inflation than that of a standard linear model.

The result of this empirical chapter have several important policy implications for the Chinese government and the PBOC. These will be discussed in detail in the concluding chapter, Chapter 6.
Chapter 4. The IS Curve - Examining Monetary Policy Transmission in China

4.1 Introduction

The dynamics of monetary policy transmission is arguably the most comprehensive and yet rapidly expanding research area in the discipline of macroeconomics. Taylor (1995) describes the monetary policy transmission (MPT) channel as the process in which a central bank’s monetary policy instrument(s) exert influence on macroeconomic variables such as price levels, the level of output and employment. In most advanced economies, the operating target for the conduct of monetary policy is the interest rate. For example the Federal Reserve have the Fed Funds rate, the Euro Area has the Euro Overnight Index Average (EOINA) and the Bank of England the base rate or the BOEBR. It has been argued however that the Chinese central bank, the Peoples Bank of China (PBOC), uses a variety of different policy instruments (both quantitative and qualitative) and so the use of a single interest rate variable may not be an accurate representation of the monetary stance (see for example Geiger 2008, He & Pauwels 2008 and Ma 2014). While some researchers suggest that continued liberalisation in the financial sector have improved its effectiveness (Fernald et al 2014), most studies have found that the interest rate channel in China has been largely ineffective. Since the reforms in 1978, the foundations of Chinese monetary policy have been built on a fixed exchange rate, strict controls on capital flows and a wide selection of administrative and qualitative policy tools. Therefore, a composite monetary policy index (MPI) may give a more accurate representation of the central bank’s policy stance.

Over the past thirty years, Chinese macroeconomic dynamics have been characterised mainly by high GDP growth accompanied by erratic swings in its business cycle fluctuations. Despite average growth of almost 10% per annum over the last three decades, Chinese output volatility has remained consistently high. An IMF (2011) paper states that Chinese output volatility is now twice as high as that of the United States. In the recovery from the Great Recession of 2008-09, China also faced serious credit fuelled inflationary concerns. Chinese monetary authorities in turn addressed this by raising banks’ reserve requirement ratios. However, in the pursuit of higher financial openness and exchange rate stability, China is
facing the crucial trade-off of having to give up monetary policy independence. This is a perfect example of the trilemma or ‘impossible trinity’ problem.

With this in mind, understanding the PBOC’s policy instruments of monetary policy is important in examining how the transition mechanisms affect the real economy. To fully analyse what drives this business cycle behaviour in China, it is important to carry out a robust study of the relationship between monetary policy, the credit market and the real economy while allowing for the “China specific” characteristics. It is also interesting to examine if any of these relationships have changed over time during the estimation period, 1991-2014, given the large number of reforms that occurred in that period. This chapter will attempt to do so by estimating different variations of an Investment Saving (IS) curve - both a traditional interest rate IS curve and a model estimated using a composite policy index that has been calculated using a Kalman Filter in a State Space Model (SSM) form are estimated. This index should give a more accurate representation of the instruments at the disposal of the PBOC. This chapter will also test, and account for where appropriate, structural breaks, non-linearity and asymmetry in the time series. This will allow us to determine if the response or effect of monetary policy has changed or switched in any significant way.

The chapter makes three main findings. First of all, unlike the majority of the literature in this area, the results find that a standard IS curve equation using a simple PBOC lending rate has a statistically significant impact on the real economy, albeit a small one. Secondly, a composite measure of the monetary policy instruments would seem to give a better explanation of the monetary policy transmission channel, once structural breaks, asymmetry and non-linearity are accounted for. The breakpoint model finds that Chinese monetary policy reaction has declined since 1994Q4 and it is suggested that this is the result of the adoption of the dollar peg in 1994. Finally, the results of the Markov switching model indicate that the PBOC’s monetary policy instruments had a much stronger effect when the economy was operating at or above potential (positive output gap) but had no significant effect on the real economy when output was operating below potential (negative output gap).

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54 The impossibly trinity states that an economy may choose two but not all three of the policy goals of monetary policy independence, a fixed exchange rate and full capital mobility. The theory of the impossible trinity has been discussed in Chapter 2 (page 36) and will be examined empirically in Chapter 5.

55 This technique is explained in the context of this thesis in Section 4.4 (page 73). A general overview of the technique is also discussed in Appendix E (page 143).
The chapter is structured as follows. Section 4.2 gives an overview of the literature on monetary policy transmission in China during the reform period. Section 4.3.1 outlines the methodology used in estimating our IS curve while 4.3.2 outlines the data used in our estimations. Section 4.4 gives a detailed description of the estimated monetary policy index (MPI). Section 4.5 estimates the various IS models and comments on the results of each and finally, Section 4.6 concludes.

4.2 Literature Review

A number of seminal papers have been written relating the level of aggregate demand to monetary policy. Bernanke & Blinder (1992), Blanchard (1990) and Friedman (1995) are all good examples of the theory that in advanced economies, the level of real output is highly responsive to monetary policy. There is however a separate branch of research which suggests that monetary policy has had little or diminishing impact on the real economy for example Goodhart & Hofmann (2005).

The New Keynesian (NK) model of monetary policy has become the standard tool for the analysis of monetary policy. This model consists of a Phillips curve, an IS curve and a monetary policy rule.\(^{56}\) According to Goodhart & Hofmann (2005), the IS Curve represents the intertemporal Euler consumption equation. It relates the output gap to the expected future output gap and the real interest rate, where the higher the interest rate, the lower the output. A great deal of research on this topic in China has focused on understanding the impact of interest rate changes on investment, which accounts for a particularly large share of GDP and growth in China and is an important driver of business cycle volatility (Conway et al 2010, Liu & Zhang 2010, Kuijs 2006). Chinese authorities have traditionally relied mainly on administrative instruments and an array of both qualitative and quantitative measures in conducting monetary policy, with interest rates playing a less prominent role (Koivu 2005). So far, the majority of the literature has supported this argument as macroeconomic based evidence of a significant negative relationship between interest rate change and capital formation in China has been weak. Geiger (2006) argues that changes in interest rates have limited impact on aggregate macro variables and that the transmission of monetary policy via the interest rate channel is distorted. Laurens & Maino

\(^{56}\) See Chapter 1 (page 3).
(2007) argue that there is no significant link between Chinese short term interest rates and movements in GDP. Mehrotra (2007) examines the role of interest rate channels in Japan, Hong Kong and China using a structural VAR model and finds that while there is quite strong evidence of the interest rate channel as a monetary policy tool for both Japan and Hong Kong, the same cannot be said for the Chinese data. The limited importance of the interest rate channel in China is attributed to the implementation of interest rates by administrative measures rather than market-determined interest rates.

The majority of studies analysing aggregate demand in China have predominantly used standard linear models and have found little or no evidence of a relationship between output and monetary policy. Koivu (2009) argues that the reforms and structural breaks during the estimation period of 1998 to 2007 prevented the estimation of a stable credit demand equation for China. To remedy this, the author estimates the model across two sub-sample periods, accounting for these structural breaks and reforms. The results seem to support the findings of previous studies that the link from interest rates to real economy is still quite weak in China. The author did however find that the link had strengthened towards the end of the time period, suggesting that interest rates have increased in importance with continued reforms in the Chinese financial sector. Qin et al (2005) find that the overall impact of monetary policy on the real sector of the macro economy is small and insubstantial, suggesting that these instruments are not effective monetary policy tools for controlling output, investment or employment in China. In contrast to this, many authors have found that there is a negative link between interest rates and macroeconomic aggregates in China. Girardin & Liu (2007) use a VAR model to investigate the relationship between interest rates and output in China and find that a negative relationship does exist, particularly in the latter half of the sample period of 1997-2005. While Conway et al (2010) argue that an IS equation for China is difficult to estimate, the author’s estimation for the period 2000-2007 find that both the interest rate and the exchange rate have a statistically significant impact on the real economy in China, even if this impact is relatively small.

There has been very little agreement in the mainstream literature regarding the asymmetric effect of monetary policy i.e. whether monetary policy has a greater effect across different stages of the business cycle. Using US data, Ravn & Sola (2004) and Weise (1999) find that the transmission of monetary policy is very much symmetric. In a recent paper Tenreyro & Thwaites (2013) found that monetary policy transmission has asymmetric effects
with the former finding a greater effect during recessions with the latter having more powerful effects on output, and inflation, in an expansion. Dolado et al (2005), Peersman & Smets (2001), Aragon et al (2009) and more recently Barigozzi et al (2014) have also investigated the topic of asymmetric monetary policy in Euro area economies. Despite these studies, across Europe and the US, no real consensus has been reached in this area of research and as a result, the topic along with its policy implications has been largely ignored in the mainstream monetary policy literature. This chapter will add to this body of research by testing and accounting for asymmetry in the Chinese economy over the last twenty five years. The huge difference between the Chinese economy and the US or Euro Area require innovative and perhaps unconventional tools to investigate the transmission channel in China however. It is also worth noting that the presence of structural breaks, changes, non-linearity’s and asymmetries in the transmission channel may be even more prominent in China. There are a many reasons to make this inference. This chapter examines the monetary policy reactions of the PBOC since late 1991, which is often regarded as the start of China’s ‘Second Reform Era’ (see page 16). During this period, the PBOC endeavoured to pursue a more market oriented monetary policy framework, including the growing use of indirect instruments. The period also coincided with other institutional reforms and changes which may have greatly affected the monetary policy transmission channel over time.

While there has been a great deal of literature concerned with Chinese economic policy (in particular the effect of changes in exchange rate policy), less attention has been paid to estimating an indicator for the monetary policy stance and very few have accounted for the asymmetries that these policies have on output. Xiong (2012) computes a monetary policy index using an ordered probit model but stops short of differentiating between asymmetric responses of the PBOC’s actions due to changes in the state of the economy. The author states that this warrants further investigation. Girardin et al (2014) build on the work of He & Pauwels (2008) and Xiong (2012) by constructing an aggregate measure of China’s monetary policy stance using price, quantitative and administrative measures. Finally, Petreski & Jovanovic (2012, 2013) created a monetary-policy index using a weighted average of the quantitative and the qualitative instruments, which is in turn included in the model instead of the interest rate. The estimation of the Chinese policy instrument in this thesis is

57 Argument made by Tenreyro & Thwaites (2013) who point to examples such as Christiano et al (2005) and Woodford (2003).
58 An ordered probit model in this case assigns a number depending on the type of policy that is observed or believed to have been carried out. So, -1 is contractionary, 0 is neutral and +1 expansionary.
most similar to this technique as it also uses a Kalman filter to extract the qualitative variables. While these papers have focused on finding an appropriate measurement of monetary policy in China, one oversight in this area of the literature has often been the failure to account for structural breaks, asymmetries and non-linearity in the transmission process. As has been discussed, this could be particularly relevant to an economy like China which has undergone significant change. To my knowledge, this research is the first to employ both a linear model with multiple structural breaks and a non-linear technique (MS model) to the transmission process along with a composite index of the monetary policy stance.

4.3 Methodology & Data

4.3.1 Methodology

The traditional IS curve takes the form of Equation 13 below. The derivation of the IS curve to this form can be found in Appendix D (page 140).

\[
\bar{y}_t = E_t (\bar{y}_{t+1}) - c [i_t - E_t(\pi_{t+1})] + v_t
\]

(13)

Where \(\bar{y}_t\) is the output gap, \((i_t - E_t(\pi_{t+1}))\) is the real interest rate, \(v_t\) is a demand side shock and \(c\) is the response of output to changes in the real interest rate. Equation 13 is a purely forward looking equation and relates the output gap to the expected future output gap and the real interest rate. In empirical applications however, purely forward looking models have been found to be inconsistent with the dynamics of aggregate demand (Estrella & Furher 2002). Therefore, a backward looking specification is often preferred in order to match the lagged and persistent responses of inflation and output to monetary policy measures that are found in the data (Rudebusch 2002). Backward looking specifications have been used in many empirical studies such as Fuhrer & Moore (1995), Rudebusch & Svensson, (1998), Rudebusch (2002) and Goodhart & Hofmann (2005). We can rewrite the equation as;

\[
\bar{y}_t = a + b(\bar{y}_{t-1}) - c[(i_{t-1}) - (\pi_{t-1})] + dv_t
\]

(14)

This purely backward-looking specification of the Chinese IS equation was chosen to obtain dynamics that match those of available economic data most consistently\(^{59}\). Macroeconomic

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\(^{59}\) Preliminary estimations of the Chinese IS curve also indicated that the backward looking model was a better fit to the data.
data usually shows a high degree of persistence in both, inflation and output (Estrella & Fuhrer 2002). According to Ball (1999, p. 128) the advantage of the backward-looking specification is that it “is similar in spirit to the more complicated macro econometric models of many central banks.”

Since the PBOC have adopted a wide range of monetary policy instruments over the last three decades, the use of a single variable to adequately capture monetary policy stance may not be an appropriate measure. A good measure of monetary policy stance should be able to indicate, either qualitatively or quantitatively, whether policy is becoming contractionary, expansionary or remaining unchanged (Xiong 2012). Most studies in this area focus on the movement of a single policy variable such as the lending or the deposit interest rate (Xie & Xiong 2003, Conway et al 2010) or the M2 (Burdekin & Silkos 2008, Koivu 2008). It is commonly accepted that monetary policy in China consists of both quantitative instruments (interest rates, deposit rates, reserve requirement etc.) and qualitative instruments. Qualitative instruments include, persuasion, telling banks which companies to lend to etc. This is often referred to as “window guidance”. This policy uses “benevolent compulsion” to persuade banks and other financial institutions to stick to official guidelines. Central banks put moral pressure on financial players to make them operate consistently with national needs (Geiger 2008). This usually involves influencing market participants through announcements rather than a set of strict rules. Many authors including Goodfriend & Prasard (2006), Bell & Feng (2013) and Girardin et al (2014) have emphasised the importance of these qualitative instruments in the conduct of Chinese monetary policy, but the problem for a modelling point of view is that there is no data available for such instruments. How can one model or quantify if the PBOC inform a particular industry or company to follow their instructions? Therefore this ‘qualitative’ instrument variable must be calculated. Once predicted, this series can be used to create an index composed of both the quantitative and qualitative instruments that would more accurately represent the monetary policy stance of the PBOC. The technique of building an index for monetary policy using a variety of techniques has been carried out by Gerlach (2007), Petreski & Jovanovic (2012) and Girardin et al (2014).

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60 The issue of forward and backward looking specifications is also discussed in Chapter 1, see pages 5-6.
4.3.2 Data

The variables used in this chapter’s estimations are plotted in Figure 18. As in Chapter 3, seasonal factors have been adjusted for where appropriate. The time period of 1991Q2-2014Q3 corresponds with the start of the “Second Reform Era”. Table 6 reports the unit root tests for all the variables used in our estimations. The results confirm that all variables pass the test for integration of order zero (I~ (0)) and are therefore stationary. This includes the constructed monetary policy index (calculated in the next section of this chapter), which is a variable that represents the change in the PBOC’s monetary policy variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>1 lag</th>
<th>2 lags</th>
<th>3 lags</th>
<th>4 lags</th>
<th>5 lags</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Gap</td>
<td>-2.60* (0.09)</td>
<td>-3.23* (0.04)</td>
<td>-3.50** (0.03)</td>
<td>-5.76** (0.04)</td>
<td>-3.05** (0.04)</td>
</tr>
<tr>
<td>Real Interest Rate</td>
<td>-2.60* (0.09)</td>
<td>-3.14** (0.03)</td>
<td>-2.99** (0.05)</td>
<td>-2.19 (0.14)</td>
<td>-2.73** (0.05)</td>
</tr>
<tr>
<td>Demand Shock (Δ Exports)</td>
<td>-4.54*** (0.00)</td>
<td>-4.82*** (0.00)</td>
<td>-5.69*** (0.00)</td>
<td>-3.92** (0.02)</td>
<td>-3.19** (0.05)</td>
</tr>
<tr>
<td>Monetary Policy Index</td>
<td>-5.07*** (0.00)</td>
<td>-4.35*** (0.00)</td>
<td>-4.84*** (0.00)</td>
<td>-3.76*** (0.00)</td>
<td>-2.87* (0.09)</td>
</tr>
</tbody>
</table>

Notes: Rejection of the unit root hypothesis at the 10, 5 & 1% level is indicated with *, ** & ***. P-values are in parenthesis. Critical values for test with constant are -2.5, -2.8 & -3.4

The real interest rate is calculated as \((i_t - \pi_t)\) where \(i_t\) is the lending interest rate and \(\pi_t\) is the annual change in quarterly CPI. Both of these series are available from the International Monetary Fund International Financial Statistics (IMF IFS). For the excess demand variable, the output gap is used. As mentioned in Chapter 3, pages 42-43, The Chinese NBS publish quarterly GDP data for China but this data is only available since 1992. Therefore, the output gap calculated by Oxford Economics Global Economic Databank is used, details of which can be found in Chapter 2 (page 43) and in Appendix B (page 134).
For the demand shock, Chinese export data (seasonally adjusted) from the IMF IFS is used. The huge importance of China’s exports to its growth model over the last two decades has been discussed extensively in the literature (Liu et al 2002, Guo & N’Diaye 2009 and Amiti & Freund 2010 as well as Chapter 2 of this thesis), and therefore this is the most logical and appropriate demand shock for the Chinese economy. As has been mentioned, the PBOC relies on a basket of different policy options in the conduct of monetary policy. Therefore, a monetary policy index is required to accurately examine the stance of the PBOC. As no data set for such an index exists, this will be calculated using the Kalman filter technique as in Garrett (1995) and Petreski & Jovanovic (2012, 2013). Given the importance of this variable for the analysis of China’s monetary policy and its importance to the overall context of this thesis, Section 4.4 describes the theory, rationale and calculations behind this variable.
4.4 China’s Monetary Policy Index

4.4.1 Unobserved Components Model

Quantifying unobserved variables is a common problem in empirical research. Often in macroeconomics, we come across variables that play an important role in theoretical models, but which we cannot observe directly. Unobserved component models (UCMs) have been used in economic research in a variety of problems when a variable, supposed to play some relevant economic role, is not directly observable. While this particular variable may not be directly observable, the unobserved component model (using a Kalman filter) allows us to predict how this unobserved variable might be behaving. For example, unobserved components have been used in modelling agents’ reaction to (permanent or transitory) changes in the price level (Lucas 1976), in modelling credibility of the monetary authority (Weber 1992) and in measuring the persistence (or long-term effects) of economic shocks (Cochrane 1988). The statistical treatment of unobserved components models is based on the State-Space Model (SSM) form. In the SSM, the unobserved components, which depend on the state vector, are related to the observations by a measurement equation. A transition equation then models the dynamics of the unobserved variables or states. While linear regression models use exogenous variables to distinguish the explained variation from the unexplained variation, SSM’s rely on the dynamics of the state variables and the linkage between the observed variables and state variables to draw statistical inference about the unobserved state. This allows us to estimate the unknown parameters of the model. The Kalman filter is the basic recursion for estimating the state, and hence the unobserved components, in a linear State-Space model (Harvey et al 2004). The useful thing therefore about the unobserved components model is that if the unobserved variable is closely linked with an observed variable, it is possible to predict the value of that variable from the observed values. The purpose of this technique therefore in this thesis, is to make inference about the unobservable policy instruments that the PBOC carry out given a set of observable policy instruments.

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61 Details on the usefulness of the UCM and the Kalman filter were sourced from Whelan (2015)
62 The Kalman filter is an iterative algorithm, used for many computational purposes, including estimating unobserved components models. Additional information on this technique can be found in Appendix E (page 143).
The PBOC’s Monetary Policy Actions

Compared to the single policy lending instruments often used by central banks in advanced economies, the PBOC has made use of a broad range of monetary policy tools. Along with the traditional monetary tools, the PBOC performs “window guidance”, sets lending quotas to pressure banks into restricting or expanding their credit, uses treasury bills issuance, as well as bank deposits and interest rates all to regulate money supply. We can categorize the monetary policy tools into two categories, quantitative and qualitative.

1. **Quantitative monetary policy tools**, often known as general tools, are the instruments used most often by advanced central banks and monetary authorities. These include bank lending and deposit rates, reserve requirements, open market operations etc. The quantitative instruments used in this thesis were chosen based on information from various People’s Bank of China official publications. For example;

   “The monetary policy instruments applied by the PBOC include reserve requirement ratio, central bank base interest rate, rediscounting, central bank lending & deposit rate, open market operations and other policy instruments specified by the State Council”(For a more detailed explanation of the individual instruments employed by the PBOC, see Chapter 5, Table 11, page 96) PBOC, Monetary Policy Instruments (2015).  

2. **Qualitative monetary policy tools**, described as “selective tools”, often involves direct administrative pressure on financial players to make them operate consistently with national needs (Geiger 2008). This style of institutional coercion is one of the PBOC’s unique characteristics and it reflects China’s hierarchical order. It also makes the monetary policy reactions of the PBOC very difficult to quantify and model accurately. The most well-known of these instruments is “window guidance”, also known as “moral suasion” or “jawboning”. Based on interviews undertaken with former and current bank officials, Bell & Feng (2013) claim that the usual form of window guidance is for the PBOC to convene monthly or unscheduled meetings with representatives of selected institutions. At these meetings, it is widely

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63 Open market operations (OMO) are not included in our estimation of the MPI for the simple reason that it followed the same path as the base rate and so any change in OMO would be captured by the dynamics in the base rate.


65 There are several other direct control instruments that a central bank can use. These included credit controls, (for example lending ceilings and floors), prudential guidelines (informing commercial banks to exercise particular care in their operations in order that specified outcomes are realized etc.)
accepted that the PBOC officials persuade commercial banks to follow certain paths such as credit restraint or expansion, increased savings mobilization and promotion of exports through financial support, which otherwise they may not do, on the basis of their risk/return assessment. Despite the phrase guidance, which implies a voluntary aspect in the system, the PBOC had a major influence on the lending decisions especially of the four state-owned commercial banks (Ikeya 2002).

A key consideration of this chapter therefore is how to quantify the latter of these two monetary policy tools i.e. how to link the unobserved variables (qualitative) to the observed variables (quantitative)? Let us suppose that the Chinese money supply (M2)\(^{66}\) moves in a way that would be consistent with a certain monetary policy response. Let’s also assume however, that none of the standard quantitative policy instrument (interest rates, open market operations, reserve requirement rates etc.) that we would expect to influence M2 can be held accountable for the deviations. It is therefore logical to assume that these unobserved qualitative variables might be responsible for changes in the M2. For a more accurate prediction of the unobserved variable, we also need to include any other factor that may influence the level of Chinese M2. Therefore, the exchange rate and changes in GDP are also included as observables in the measurement equation\(^{67}\). Of course, this does not mean that all changes in M2 not explained by the measurement equation variables will be explained by this unobserved variable, as there is probably a lot of noise in the M2 data. There is however, likely to be very useful “signal” or “noise free” data. The Kalman filter is therefore used to separate the best signal from the noise.

4.4.2 Set Up of the Unobserved Components Model

Equation 15 and 16 describe both the measurement and transition equations respectively. Quarterly changes in M2 is chosen as the dependent variable in the measurement equation

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\(^{66}\) M2 is chosen because qualitative instruments are likely to be reflected on to broad money supply (Petreski & Jovanovic 2012)

\(^{67}\) Changes in the exchange rate are included due to the heavily managed exchange rate regime which would certainly have had an effect on the supply of money. Changes in GDP are included in the equation as changes in the output of an economy will also have an effect on M2.
because qualitative instruments are likely to be reflected on to broad money supply\textsuperscript{68} and is expressed as a function of both the quantitative and the qualitative monetary policy instruments used by the PBOC. The transition equation then models the unobservable qualitative instruments as a first-order autoregressive process (AR (1)). The qualitative instrument series is obtained by a Kalman filter estimation of this money demand function for China. The two equations are written in the following form:

**Measurement equation:**

\[
\Delta M2 = \beta_1 + \beta_2 \text{ exchange rate} + \beta_3 \text{ base rate} + \beta_4 \text{ reserve requirement} + \beta_5 \text{lending rate} + \beta_6 \text{ deposit rate} + \beta_7 \text{GDP} + \beta_8 \text{Qual} + \epsilon_{t1}
\]  

(15)

**Transition equation:**

\[
\text{Qual} = \beta_9 \text{Qual}(-1) + \epsilon_{t2}
\]  

(16)

In the above model, the measurement equation, *Equation 15*, links the quantitative variables (\(\beta_3 \text{ base rate} + \beta_4 \text{ reserve requirement} + \beta_5 \text{lending rate} + \beta_6 \text{ deposit rate}\)) and changes in the exchange rate and GDP (\(\beta_2 \text{ exchange rate} + \beta_7 \text{GDP}\)) to an unobserved state variable (\(\beta_8 \text{Qual}\)). The transition equation then describes the dynamics of this qualitative instrument\textsuperscript{69}. This \text{Qual} variable in both *Equations 15* and *16* is the vector of the unobserved variables and describe how these unobserved variables evolve over time. The error terms \(\epsilon_{t1}\) & \(\epsilon_{t2}\) are the monetary policy shock and the shocks to the qualitative instruments respectively. The set-up of this UCM assumes that the only variable affecting the quarterly growth rate of M2 that can have an AR (1) structure is our unobserved variable, and treats all other factors as shocks. While using this assumption to define our series for the qualitative variable may at first seem slightly naive, it is justified for the simple reason that the key variables which may have an AR (1) structure and still effect changes in M2 have already been included in the measurement equation (exchange rate, changes in GDP, discount rate, reserve requirement, lending rate and deposit rate). Therefore, it is logical to assume that the only important variables that remains for quarterly changes in M2 is this qualitative variables.

\textsuperscript{68} This is the case as qualitative instruments involve the central bank persuading commercial banks to take certain steps through window guidance without itself making any changes to benchmark rates.

\textsuperscript{69} The starting values for the parameters in the measurement equation were chosen from OLS regression which is the standard procedure for an estimation of this type.
4.4.3 Estimating the Qualitative Variable

The results of the estimations are as follows;

*Measurement equation:*

\[ \Delta M2 = 7.5^{**} - 0.04 \text{ exchange rate} + 0.32 \text{ base rate} + 0.10 \text{ reserve requirement} - 1.4^* \text{lending rate} + 0.95^{***} \text{ deposit rate} + 0.05 \text{GDP} + \text{Qual} \]  

(17)

*Transition equation:*

\[ \text{Qual} = -0.02 \text{ Qual}(-1) \]  

(18)

The measurement equation results show that while the GDP growth rate and changes to the exchange rate are correctly signed, their coefficients are not significant. The base rate and the reserve requirement ratio (RRR) are insignificant and also incorrectly signed. In fact, of all the monetary policy tools included in the equation, only the deposit rate is correctly signed and significant. This would suggest that for the most part the quantitative variables have played a limited role on the Chinese money supply. This equation would obviously suffer from multicollinearity problems however, and so the interpretation of its results must be treated with caution.

The transition equation on the other hand will give the prediction of the qualitative instruments used by the PBOC. Technically speaking, the transition equation identifies latent autoregressive process of order 1 (AR(1)) that affects money growth (Petreski & Jovanovic 2012, 2013). The predicted series calculated from the estimation can be seen in the bottom centre panel of *Figure 19A* (page 79). This series should, broadly speaking, correspond to the “selected” monetary policy actions of the PBOC. As a simple example, the marked increase and decline in the 1992-95 periods can be accredited to Deng Xiaoping’s southern tour. In January 1992, Deng Xiaoping toured the southern areas of Wuchang, Shenzhen, Zhuhai, and Shanghai and made a series of important speeches on reform and opening up of the economy. He encouraged growth, prompted foreign investment and called on China to embrace all aspects of a capitalist market. In late 1992, rapid growth of money supply and credit was noticeable, and hence, the Central Committee of the Chinese Communist Party and the State Department announced two related commands. Regional governments were ordered

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70 ***,** and* denote significance at the 1%, 5% and 10% level of significance respectively.
to control the credit quotas instead of the central bank. The flow of funds among regions was also restricted (Sun 2013). Despite these commands, provinces continued to pursue the regional PBOC’s for credit, and most folded under this pressure, despite the order from Beijing. The then vice Premier Zhu Rongji, fed up with the inability of the Governor of the People’s Bank to control the money supply and the price level, fired him and personally assumed the position of Governor of the PBOC. Zhu Rongji embarked on a policy of strict macroeconomic austerity in an attempt to deliver a more controlled money supply. To take another simple example, the spike in the 2008-09 periods captures the stimulus package the PBOC undertook to prevent the effects of the financial crisis in China. Further details of this stimulus package can be found in Chapter 2 (page 36) and Chapter 5 (page 109) of this thesis. From a simple observation of our index, it would appear that our ‘qualitative’ variable measure has succeeded in capturing some of the important “unobservable” Chinese monetary policy movements.

We now have a data set for both the qualitative and quantitative instruments used by the PBOC. All five of these variables are plotted in Figure 19A (page 79). To calculate the monetary policy index (MPI), we need to construct a measure of the change of these variables as this will give a more accurate representation of the change in the PBOC monetary policy stance. The change in each of these variables is plotted in Figure 19B (also page 79) and the index itself is calculated in Section 4.4.4 (page 80) of the chapter.
**Figure 19A - PBOC Quantitative & Qualitative Monetary Policy Variables**

- **Base Rate**
- **Deposit Rate**
- **Lending Rate**
- **Reserve Requirement Ratio (RRR)**
- **Qualitative Instruments**

**Figure 19B - Changes in the Quantitative & Qualitative Monetary Policy Variables**

- **Change in the Base Rate**
- **Change in Deposit Rate**
- **Change in Lending Rate**
- **Change in RRR**
- **Change in Qualitative Instruments**

*Source (19A & 19B): PBOC website, IMF IFS, NBS and author’s calculations*
4.4.4 Calculating the Index

Having obtained an estimated series of the qualitative series variable, the monetary policy index can be then be constructed. Firstly, the coefficient of variation of the five instruments, both qualitative and quantitative, is calculated and their sum normalised to unity. The coefficient of variation is a statistical measure of the dispersion of data points in a data series around the mean. It is a useful statistic for comparing the degree of variation from one data series to another, even if the means are drastically different from each other. This technique allows us to examine and compare the degree of variation of the five series. The coefficient of variation for the five variables can be seen in Table 7. We can clearly see that the main monetary policy tools mentioned by the PBOC – deposit rate, lending rate discount rate and reserve requirement –play a relatively minor role and seem to change less infrequently when compared to our qualitative instrument. The addition of the qualitative instrument variable clearly shows its importance in the role of monetary policy in China. This is confirmed by examining the changes in all policy variables (Figure 19B) which clearly shows that the qualitative instrument variable changes far more frequently than the other four quantitative variables. The final monetary policy index (MPI) is then calculated as a weighted average of the changes in the five policy instruments using the coefficient of variation values (Table 7) as weights. This is done by multiplying the normalised series of each variable by the coefficient of variation and then getting an average across all five variables. Figure 20 plots the final MPI which will be used in the estimations that follow. It should be noted that an increase in this index corresponds to an expansionary monetary policy stance and a decrease to a contractionary stance. This is due to the setup of the weightings of each of the variables. Therefore, we would expect to see a positive sign in the IS curve estimations as opposed to the usual negative sign as expected with the standard interest rate equation.

<table>
<thead>
<tr>
<th>Table 7 - Coefficient of Variation of Policy Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
</tr>
<tr>
<td>MPI_i</td>
</tr>
</tbody>
</table>

Source: Author’s calculations. The coefficients have been normalised

71 The five instruments are changes in the four quantitative variables (deposit rate, lending, base and reserve requirement rate) and changes in the estimated qualitative variable.
4.5 Estimations

4.5.1 Standard OLS Estimation

Real Interest (Lending) Rate

Table 8 (page 83) reports the results of the traditional IS curve equation for China which uses a standard single policy variable (the lending rate) as a measure of the monetary policy stance of the central bank. This regression represents Equation 14 in Section 4.3.1 of this chapter. While this is the specification most often used to examine monetary policy transmission in advanced economies, literature has mostly found that its significance will be weak for the Chinese economy (see Section 4.2, page 66-69).

The lag of the output gap is large and highly significant indicating that shocks to the output gap are quite persistent. The real interest rate is correctly signed and highly significant which suggests that the lending rate set by the PBOC did have an effect on the real economy. While the coefficient of 0.06 indicates that the magnitude of this effect is quite small, this can be examined further by estimating the standard deviation (S.D.) of variables. A 1% S.D. in the interest rate results in a 0.12% change in the output gap. The effect of a shock to demand (change in exports) has no effect on the output gap during the estimation period. The

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72 These are calculated using the summary statistics which are provided in the Appendix F (page 145). For details on calculation, please see Chapter 3, (page 54).
presence of structural breaks can also be tested by applying the Quandt-Andrews SupF statistic, as done in Chapter 3 of this thesis. This model passes the tests for structural breaks which suggests that this standard Chinese IS curve is characterised by a stable and linear relationship. This is an interesting finding and is at odds with the majority of the research in the area. The result suggests that a standard IS curve maybe an appropriate model for examining the monetary policy transmission channel in China. There are explanations one can offer as to why the magnitude of this relationship may be small however. The underdevelopment of the banking system, market segmentation and the ineffectiveness of the credit channel along with the fact that the PBOC has also relied on many different tools in the conduct of monetary policy are all possible explanations. This issue will be dealt with in the next section of this chapter.

**Monetary Policy Index (MPI)**

As the PBOC have been known to use a variety of different policy instruments, an index representing these may give a better and more accurate representation of China’s monetary policy stance. The augmented IS curve model, estimated using the monetary policy index (MPI) that was estimated in Section 4.4, then takes the following form;

\[
y_t = a + b(y_{t-1}) + c(MPI_t) + d\nu_t + \epsilon_t
\]  

(19)

The estimation of this augmented IS curve can also be seen in Table 8. Again, the persistence of a shock to the output gap is very high. The results also seem to indicate that a change in this combined index has a stronger effect on the real economy than the interest rate had with a coefficient of 0.12. The positive sign suggests that an increase in the index corresponds to looser monetary policy and a decrease to tighter monetary policy. As before, we can examine more rigorously the relationship between the output gap and the MPI by examining the standard deviation (S.D) of the variables. A 1% S.D. in the MPI leads to only a 0.08% change in the output gap, a change that is actually smaller than that calculated by the interest rate IS curve. The validity of the results are however compromised by the presence of a structural break. This is observed by the highly significant value of the Sup F test in Table 8. In an attempt to remedy this problem, the next section of the chapter

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73 See page 51 for a description of this technique.
74 This can be seen in Figure 19A & 19B and reflects the setup of calculating the index as described in Section 4.4.
estimates the policy index IS curve using models that allow for structural breaks and switching between different states or regimes.

TABLE 8 - IS CURVE ESTIMATION - OLS ESTIMATION (1991Q2-2014Q3)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Interest Rate (14)</th>
<th>Monetary Policy Index (19)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variable: China's Output Gap</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.01*** (0.00)</td>
<td>-0.01 (0.01)</td>
</tr>
<tr>
<td>Output Gap Lag</td>
<td>0.90*** (0.03)</td>
<td>0.98*** (0.03)</td>
</tr>
<tr>
<td>Real Interest Rate (Lending)</td>
<td>-0.06*** (0.01)</td>
<td></td>
</tr>
<tr>
<td>Monetary Policy Index (MPI)</td>
<td></td>
<td>0.12** (0.04)</td>
</tr>
<tr>
<td>Demand Shock (Exports)</td>
<td>-0.01 (0.10)</td>
<td>0.01*** (0.01)</td>
</tr>
</tbody>
</table>

\[ R^2 \]
0.94 0.94

LM F-Stat 2.26 2.11

SupF Stat 14.51 17.39*** (no break) (1994Q4)

Notes: ***, ** and * denotes significance at the 1, 5 and 10% respectively. HAC standard errors are in parenthesis.

4.5.2 Multiple Breakpoint Model

As in Chapter 3, this chapter uses the Bai-Perron (1998), (2003) procedure. Applying this procedure to the augmented IS curve with the calculated policy index, this gives us the following IS curve equation with \( m \) breaks

\[
\bar{y}_t = a_1 + b_1 \bar{y}_{t-1} + c_1 MPI_t + d_1 v_t + e_t, \quad t = 1, \ldots, T_1 \tag{20}
\]

\[
\vdots
\]

\[
\bar{y}_t = a_m + b_m \bar{y}_{t-1} + c_m MPI_t + d_m v_t + e_t \quad t = T_{m+1}, \ldots, T \tag{21}
\]
where the breakpoints \( (T_1, ..., T_{m+1}) \) are treated as unknown. The Bai-Perron estimation is based upon least square estimates of \( a_i, b_i, c_i & d_i \).

The results of the multiple breakpoint regression can be seen in Table 9.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.01 (0.01)</td>
<td>0.01* (0.01)</td>
</tr>
<tr>
<td>Output Gap Lag</td>
<td>0.99*** (0.04)</td>
<td>0.96** (0.03)</td>
</tr>
<tr>
<td>Monetary Policy Index</td>
<td>0.24*** (0.08)</td>
<td>0.07* (0.04)</td>
</tr>
<tr>
<td>Demand Shock (Exports)</td>
<td>0.04* (0.04)</td>
<td>0.01 (0.02)</td>
</tr>
</tbody>
</table>

Notes: ***,** and * denotes significance at the 1, 5 and 10% respectively. HAC standard errors are in parenthesis.

The results first of all confirm the presence of a structural break in 1994Q4. In 1991Q2-1994Q4, hereafter known as Period 1, the lag of the output gap is very high at 0.99 and significant at the 1% level. This indicates that shocks to the output gap are very persistent in Period 1. The index representing the monetary policy stance of the PBOC is highly significant in Period 1 with a coefficient of 0.24. A 1% S.D. in the policy index results in a 0.15% change in the output gap. Finally, the demand shock is significant (if only at the 10% level) in this period but has a small magnitude with a coefficient of 0.04. Examining the S.D. a 1% shock to demand in Period 1 shows it causes a 0.13% change in the output gap.

In 1995Q1-2014Q3, hereafter Period 2, the lagged coefficient on the output gap is highly significant at 0.96. The monetary policy index is only significant at the 10% level with a coefficient value of 0.07. Again, we can evaluate the magnitude of the relationship by examining the effect of a 1% S.D. on the output gap. A 1% change in the policy index in this period leads to only 0.06% deviation in the output gap. There is no significant effect of the demand shock on the output gap in Period 2.
4.5.3 Markov Switching Model

The Markov switching (MS) model has been used extensively to examine monetary policy transmission in advanced economies such as the US, UK and the Euro area. As mentioned in Section 4.2, Dolado et al (1999) Peersman & Smets (2001) and Aragon (2009) have all carried out similar studies for advanced economies but the technique has seldom been applied to the Chinese case, or indeed to other emerging market economies. This gives us a unique opportunity to examine any asymmetry or non-linearity in China’s monetary policy transmission channel. For example, the MS model may highlight the effectiveness of the PBOC’s monetary policy depending on whether the Chinese economy is operating above or below potential (positive or negative output gap). Fitting the monetary policy index IS equation to the MS framework yields the following equation:

\[
\bar{y}_t = a_{st} + b_{st}(\bar{y}_{t-1}) + c_{st}(MP_l_t) + d\nu_{t, st}
\]  

(22)

The results of the Markov switching estimation of the IS curve can be seen in Table 10 and the two identified states plotted against the output gap can be seen in Figure 21.

![Figure 21 - Output Gap with Regime Classification](image)

Source: Oxford Economics & Author’s Calculations

85
<table>
<thead>
<tr>
<th>Variable</th>
<th>State 1</th>
<th>State 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable: China’s Output Gap.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.01***</td>
<td>0.01***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Output Gap Lag</td>
<td>0.91***</td>
<td>0.70***</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>Monetary Policy Index</td>
<td>0.05</td>
<td>0.25***</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>Demand Shock (Exports)</td>
<td>0.01***</td>
<td>0.04***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>$p_{11}$</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>$p_{12}$</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>$p_{21}$</td>
<td></td>
<td>0.11</td>
</tr>
<tr>
<td>$p_{22}$</td>
<td></td>
<td>0.89</td>
</tr>
<tr>
<td>Duration of State</td>
<td>32.9 quarters</td>
<td>8.8 quarters</td>
</tr>
</tbody>
</table>

Notes: ***, ** and * denotes significance at the 1, 5 and 10% respectively. Standard errors are in parenthesis.

In State 1, the autoregressive coefficient of the output gap is high at 0.91. This indicates that shocks to the output gap are quite persistent i.e. output will be increased if output was high in the previous period. The monetary policy index (MPI) has no significant effect on the output gap in this state. The effect of the demand shock (change in exports), while significant, is very small. We can examine the relationship of the significant independent variables to the output gap further by examining the 1% S.D. A 1% S.D. in the demand shock has only a 0.06% effect. By examining both Figure 21 and the summary statistics in Appendix F (page 145–46), we can clearly see that State 1 can be characterised by a period when China’s output was operating below potential i.e. negative output gap.\(^75\)

\(^75\) Figure 21 also shows that this period of negative output gap dominates over the twenty-five year period. While this seems unusual for an economy that has grown at 9% per year, the reason behind China’s excess capacity is discussed at length in Chapter 2 (page 28 and Appendix B, page 134).
In *State 2*, the persistence of shocks to the output gap is again high but has decreased from *State 1*. The monetary policy index is correctly signed and highly significant with a coefficient of 0.25. This indicates that changes to the various policy instruments used by the PBOC had an effect on the real economy. The demand shock (changes in Chinese exports) is also highly significant with a coefficient of 0.04. A 1% S.D. in the MPI leads to a 0.33% change in the output gap. The effect of a demand shock is much stronger in *State 2* than in *State 1*. A 1% S.D. in Chinese exports leads to a 0.45% change in the output gap. *Figure 21* and summary statistics in *Appendix F* indicate that *State 2* can be described as a period when output was operating at or above potential i.e. neutral or positive output gap.

### 4.5.4 Summary of Results

From the results of the various estimations in this section, some important characteristics of the monetary policy transmission channel in China have been identified. Contrary to the majority of the literature in the area, the results find that a single policy instrument (lending rate set by the PBOC) can be used to explain the dynamics of the monetary policy transmission channel in China. The magnitude of this relationship between the interest rate and the output gap is small however. The results also found that this traditional IS curve specification was linear and stable over the estimation period. An IS curve estimated using a composite index of the policy tools used by the PBOC, (including a measure of qualitative instruments) does not improve on the standard model. However, this specification was found to contain structural breaks.

An IS curve using the multiple breakpoint model of Bai & Perron (1998), (2001) was estimated. The estimation suggested that there was a breakpoint in 1994Q4. This structural break occurs around the same time as that in the Phillips curve in *Chapter 3 (see page 50-51)*. This breakpoint corresponds to key institutional changes and reforms in the Chinese economy. These include reforms to the banking sector, reforms regarding price liberalisation and of course the adoption of the dollar peg. These changes therefore seem to have had a distinct effect on China’s monetary policy transmission channel. During the period prior to this breakpoint (*Period 1*), the policy index exerted a significant influence on the real economy. In the period after the breakpoint (*Period 2*) the same instruments played

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76 Reforms in the Chinese banking sector are discussed in greater detail in *Chapter 5*
no significant role in changes to the level of output. This is an important finding as *Period 2* (1994 onwards) included continued reform of the banking and financial sector which, in theory, should have improved both the transmission channel/mechanisms of monetary policy and the influence and autonomy of the PBOC. The reason this failed to materialise could be as a result of the adoption of the dollar peg\(^7\). It is possible that the maintenance of this fixed exchange rate has served to hinder the ability of the PBOC to influence the real economy through the monetary policy transmission channel. This point was made in *Chapter 2* and will be examined in greater detail when we look at China’s monetary policy rule in *Chapter 5*.

The final model estimated was a Markov Switching IS curve. This model differs from the breakpoint model in that it allows switching between states. It characterised the Chinese economy into in two states. The majority of the estimation period is characterised by *State 1*, in which the monetary policy index had no significant effect on the output gap. This state is mainly characterise by periods below potential output i.e. negative output gap. *State 2* on the other hand is characterised by a mostly positive output gap. The index for monetary policy action of the PBOC was highly significant in this state. These results suggest that monetary policy in China is much more effective when the economy is stronger (operating at or above potential) than when it is weaker (operating below potential). This would echo Keynes’s “*pushing on a string*” hypothesis in which he proposed that when the economy is weak (or operating below its potential level), a central bank can do little to remedy the situation. Monetary policy that is more effective when the economy is stronger and less effective when weaker is also indicative of the shape of the Phillips curve. Nonlinearity of the Phillips curve means that the effectiveness of monetary policy depends on the phase of the business cycle and that the cost of disinflation is changing. Thus, a nonlinear monetary transmission might stem from nonlinear Phillips curve (Sznajderska 2012). Egan & Leddin (2014) found that the Chinese Phillips curve was indeed nonlinear and took a concave shape. This paper mentioned that if the Phillips curve is concave, monetary policy has more real effects during high output levels (positive gap) than during periods of lower output (negative gap). Therefore, the results of this chapter seem to complement those of concave Phillips curve. This has important policy implications in terms of the trade-off between inflation

\(^7\) While officially this dollar peg was abandoned in 2005, Morrison (2010) argues that China’s exchange rate mechanism remains, in practice, a tightly managed currency peg against the dollar. In July 2015, *The Financial Times* also reported that despite progress on reforms since 2005, intervention remains a daily reality (accessed at [http://www.ft.com/cms/s/0/1e0a2620-3039-11e5-8873-775ba7c2ea3d.html?siteedition=uk#axzz3givhsTxl](http://www.ft.com/cms/s/0/1e0a2620-3039-11e5-8873-775ba7c2ea3d.html?siteedition=uk#axzz3givhsTxl))
targeting and GDP growth. These will be discussed in detail in * Chapters 5 and 6 of the thesis. The high significance of China’s growth in exports to the economy operating above potential is also an important finding. Chapter 2 mentioned that China’s high levels of investment created capacity beyond its ability to consume (i.e. excess capacity) which has often absorbed outside its borders by the exceptionally strong global demand for Chinese exports (IMF 2014). This would reiterate this arguments which points to the importance and reliance to China of exports in closing the gap between potential and actual output.

4.6 Conclusion

In examining the link between Chinese monetary policy and the real economy using different variations of the IS equation, this chapter has made several interesting findings. The results of the traditional OLS model indicate that there is a significant and stable link between the lending interest rate set by the PBOC and aggregate demand in the Chinese economy. This at odds with the majority of studies on the topic that suggest it is difficult to estimate a stable and robust aggregate demand equation for China. It is important to note however, that the size of the effect is small. This can be attributed to the following causes: the underdevelopment of the banking system, market segmentation, the ineffectiveness of the credit channel along with the fact that the PBOC has relied heavily on many different tools in the conduct of monetary policy. Given these findings, the paper therefore estimated an IS curve with a monetary policy index (MPI) composed of the tools used by the PBOC between 1991 and 2014. This index is a composite measure of the relevant variables observed to be at the disposal of the PBOC, both quantitative and qualitative, and therefore should give a much better representation of the monetary policy stance of the Chinese central bank. The presence of structural breaks however suggested that there is an asymmetry between monetary policy action and output depending on the state of the economy and the time period.

Therefore, a monetary policy index IS curve using a multiple breakpoint model was estimated. The results confirmed the presence of a break in late 1994. The results of this model suggested that the monetary policy instruments of the PBOC have had less of an effect on the level of output since this breakpoint. While this seems counter intuitive due to the increased reform in the financial sector, as well as measures which have promoted greater PBOC independence, this result is attributed to the adoption of the dollar peg in 1994.
Finally, a Markov switching IS curve, again using our monetary policy index was estimated. This technique can provide us with a different perspective on the monetary policy transmission channel as it allows for switching between different regimes or states. For example, this nonlinear technique allowed us to examine asymmetries in the monetary policy transmission channel depending on whether the economy was operating above or below potential. Testing for this type of asymmetry is important due to the under-developed nature of the Chinese financial system and due to huge amount of reform and structural change that the economy has expended. Our results suggest that there is a significant link between the monetary policy tools used by the PBOC and the real economy in State 2 of our augmented model, when output is operating at or above its potential level. This relationship breaks down when the economy switches to a level of output below potential however. Finally, our MS model seems to suggest that demand shocks had a much greater effect in State 2 than in State 1. Policy options based on the empirical results of this chapter will be discussed in Chapter 6.
Chapter 5. A Monetary Policy Rule for China

5.1 Introduction

Background

The ever increasing influence of the Chinese economy on the world stage has meant that the analysis of monetary policy and the actions of the Peoples Bank of China (PBOC) have received a great deal of attention, from both academics and policy makers. In studies of China’s monetary policy rule, the majority of researchers have used the standard model of monetary policy analysis. In the canonical New Keynesian (NK) models, monetary policy rules take the form of the Taylor (1993,1995) rule. In the Taylor rule, the central bank sets the interest rate as a function of inflation and the output gap (or unemployment rate) by linking the monetary policy instrument to deviations of inflation from its target and of output from its potential. In its simplest form, the rule implies that positive deviations of the inflation gap, or the output gap, would lead to a tightening monetary stance. In the traditional rule, an interest rate or an exchange rate channel is often used to examine the dynamics of a central bank’s monetary policy stance. For example, an increase in the interest rate would raise the cost of investment and therefore reduce aggregate demand. Similarly, an appreciation of the domestic currency would make exports more expensive and therefore reduce aggregate demand (Rudebusch 2006).

Standard economic models such as the Taylor rule are often not applicable to China however. This is because of the unique characteristics of the Chinese economy, namely, the role of the government and the structure and philosophy of the central bank. This makes the measurement of China’s monetary policy stance notoriously difficult. There have also been a large number of institutional changes and reforms which make the modelling of monetary policy cumbersome. China has embarked on a series of bold reforms of its financial sector since 1980 to make the exchange rate more flexible; expand the interbank money, bond, and stock markets; open the banking sector to more competition; and liberalize interest rates (IMF 2014a). Meanwhile, China’s monetary policy has historically been exercised through quantity controls on bank lending (window guidance) and direct instruments (reserve

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78 This argument has been made throughout the thesis. Chapters 3 and 4 both adopted augmented models to better suit the characteristics of the Chinese macro economy.
requirements) guided by monetary aggregate targets (Laurens & Maino 2007). This further complicates an estimation of a stable monetary policy rule.

The PBOC operates under the dual mandate of ‘maintaining the stability of the currency and thereby promoting economic growth’. While these objectives are similar to that of most central banks in advanced economies, the instruments that the Chinese central bank use to achieve these targets are, in themselves, quite unique (see Chapter 5 of this thesis). Since the PBOC has adopted a wide range of monetary policy instruments over the last three decades, including price based instruments, quantity based instruments and administrative instruments, it is therefore likely that no single variable can be used to adequately capture their monetary policy stance. This subject has been discussed at length in Chapter 4 of this thesis. The PBOC has been more reluctant to use the interest rate as an operating target, instead setting intermediate targets for money supply growth and the exchange rate79. Consequently, using a standard Taylor rule would not be appropriate. Another potential modelling problem is the amount of economic and political change the economy has experienced in the last twenty years. Studies of the Chinese economy often suffer from the problem of structural breaks in the time series as a result of these changes. This problem has again been well documented in the preceding chapters of this thesis. This can make a stable model of monetary policy very difficult to estimate. Moreover, as is typical in a transition economy, some important features, such as the shifting preferences and nonlinearities of policymakers’ choices, might play an important role in monetary policy conduct, and a thorough understanding of China’s monetary policy will not emerge unless these special characteristics have been effectively taken into account. Therefore, this chapter will estimate a set of augmented monetary policy “Taylor type” equations using a monetary policy index (MPI) instead of the interest rate, as in the IS curve estimations in Chapter 4. This equation is then estimated in a multiple breakpoint model and Markov switching framework. The exchange rate is also included as the PBOC’s intermediate target. Making the necessary adjustments to account for the specifics of the Chinese economy and its financial system, the chapter aims to improve the understanding of how the PBOC reacts to its main policy target variables.

79 The crawling peg which China adopts is often seen to play a very important role within the Chinese monetary policy framework (Geiger 2008). See Chapter 2 (page 32) for a detailed note of Chinese exchange rate policy.
From 1950 to 1978, the People’s Bank of China (PBOC) was the only bank in China and was responsible for both central and commercial banking. Before the Chinese economy “opened up” in 1978, the financial and banking system operated under an almost entirely centralised philosophy. With the introduction of economic reforms, pioneered by Deng Xiaoping, four “independent” banks were established in 1984 to carry out the commercial functions of the PBOC. These four banks however, remained under the remit of the state and so were “independent” in name but not in nature. In the early 1990’s, problems arose with these commercial banks in the form of huge amounts of non-performing loans due to a culture of policy lending, with “the big four” being encouraged to support often inefficient state owned companies. In January 1994, the Chinese authorities introduced three new policy banks to disburden the commercial banks from the problem of policy lending mentioned above. Prior to 1994, the intermediate targets adopted by the PBOC had been currency in circulation and the portfolio of commercial bank loans. The PBOC also began to release the statistical data for money supply in this year and gradually took it as the intermediate target with the introduction and definition of three new indicators. At the time, the interest rate was not (and still has not, as of 2015) totally liberated and did not serve as the operation target of China’s monetary policy.

While the Chinese State Council announced that the PBOC would function solely as a central bank in 1983, its central bank status was not legally confirmed until March 1995 at the 3rd Plenum of the 8th National People’s Congress. Since the law officially acknowledged the PBOC as the central bank of China on the 1st of July 1995, many private banks have been established as well as foreign subsidiaries after the ascension into the World Trade Organisation (WTO) in 2001. 1997 saw the establishment of the Monetary Policy Committee (MPC), the consultative body of the PBOC assigned to formulate, adjust and set targets for monetary policy. However, the MPC of the PBOC is very different from the Monetary Policy Committee of the Bank of England and the Open Markets Committee (FOMC) of the Federal Reserve, as it only advises on monetary policy rather than determines it. The State

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80 These are the Bank of China (BOC), the China Construction Bank (CCB), The Agricultural Bank of China (ABC) and the Industrial & Commercial Bank of China (ICBC)
81 The estimation period of this chapter begins in 1994, which corresponds conveniently to important institutional changes and reforms in the Chinese financial and banking system.
82 The three policy banks being Agricultural Development Bank of China (ADBC), China Development Bank (CDB), and the Export-Import Bank of China (Chexim)
83 M0, M1 & M2
Council has the ultimate power to decide the substantial monetary policy measures (Long 2012). Therefore, many of the PBOC’s objectives were (and are still) established directly by the government. In 1998, the PBOC underwent major restructuring and all the former provincial and local branches were abolished. In lieu of these, the PBOC opened nine regional branches in Tianjin Shenyang, Shanghai, Nanjing, Jinan, Wuhan, Guangzhou, Chengdu and Xi'an. In 2003, the 10th National People’s Congress strengthened the institution even further by approving laws and amendments which gave the PBOC more power in implementing monetary policy for safeguarding the overall stability of the economy and the provision of financial services. This coincided with the establishment of the Chinese Banking Regulatory Commission (CBRC) which was established to regulate and supervise the commercial banking sector. These amendments conclusively defined the PBOC as the central bank we see today and the organizational system was also specified.

Despite the reforms in the banking sector and the increased autonomy that the monetary authority now possess, examining the monetary policy reactions of the PBOC using standard macroeconomic models is hindered by a number of factors.

- As mentioned, the PBOC does not exclusively use the interest rate as an operating instrument, opting instead to set intermediate targets for both money supply and the exchange rate. This makes the standard Taylor rule estimation inappropriate in the Chinese case.

- Secondly, identifying the instruments used by the PBOC to conduct monetary policy is difficult. Girardin et al (2014) point to three main categories of policy instrument employed by the PBOC; 1) Price based instruments (such as interest rates on bank deposits and lending, excess reserves etc. 2) Quantity based instruments (such as reserve requirement ration (RRR) & 3) Administrative instruments (such as ‘window guidance’ which of course is difficult to estimate or model as it is not directly observable). Window guidance can be defined as exercising quantity controls on bank lending (IMF 2014). In China this takes the form of the central government setting the direction for sector development and for stimulating growth of certain industries - often propping up ineffective and inefficient state owned enterprises, thus denying

84 For a definitive outline of the structure of the PBOC see Geiger (2008)
more efficient private corporations investment. Table 11 (page 96) shows the different instruments that the PBOC has actively used over the time period.

- Finally, there is the issue of identifying structural breaks in the Chinese economic data, which is symptomatic of an economy which has changed band reformed its institutions rapidly in a relatively short period of time. These have included changes in structures of government organisations such as those of the PBOC discussed in the previous section, indicative of an economy in transition, as we have seen in Chapters 3 and 4. Structural changes in an economy and breaks in its time series make standard linear models redundant. Therefore more advanced linear estimations as well as non-linear estimations need to be carried out to get an accurate representation of monetary policy dynamics in China.
(a) **Price Based Instruments**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest rates on bank deposits &amp; lending</td>
<td>The PBOC’s benchmark deposit rate is the “ceiling” interest rates bank pay for deposits. The lending rate is the “floor” of the rates banks earn from loans. In recent years, the PBOC has made plans to further liberalize the interest rates by gradually phasing out the benchmark deposit and lending rates. This would allow for a more market-based monetary policy implementation framework.</td>
</tr>
<tr>
<td>Refinancing to commercial banks</td>
<td>In its earlier years, the PBOC lent to specialized banks (see Section 5.1) and the PBOC also allocated a borrowing quota for each bank every year. In recent years, the PBOC began to use the refinancing policy instrument to ensure financial stability and help economic transformation during the “Second Reform Era”.</td>
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</table>

(b) **Quantity Based Instruments**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reserve Requirement Ratio (RRR)</td>
<td>Introduced by the PBOC in 1984, the RRR has been increasingly used in recent years as a key policy instrument to control liquidity in the financial system and restrict relatively rapid growth of monetary and credit aggregates in the economy.</td>
</tr>
<tr>
<td>Open Market Operations (OMO’s)</td>
<td>OMOs, the purchase and sale of securities on the open market by the PBOC, were first introduced as a monetary instrument in 1993. Since 1998, with actions taken by the PBOC to develop the interbank bond markets, OMO’s have represented a critical instrument for the conduct of monetary policy in China.</td>
</tr>
<tr>
<td>Capital Controls</td>
<td>This is related to foreign exchange intervention (below). The aim of this policy instrument differs in that its aim is not to control credit allocation, but instead to quantitatively limit the financial flows between China and the rest of the world.</td>
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</tbody>
</table>

(c) **Less observable instruments**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
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<tbody>
<tr>
<td>Foreign exchange intervention</td>
<td>In simple terms, this involves controlling the level of the RMB through selling the domestic currency and buying foreign currencies to keep the foreign-exchange value lower than it would otherwise be. This policy has received a huge amount of attention, particularly from the US, who have labelled the process “currency manipulation”.</td>
</tr>
<tr>
<td>Window Guidance</td>
<td>This is the policy of the Chinese government persuading the PBOC and financial institutions to follow official guidelines. This can involve directing financial institutions on who and how much to lend. e.g. lending to certain sectors or industries, state owned enterprises etc.</td>
</tr>
<tr>
<td>Admin measures</td>
<td>This would include set limits on the price (interest rate controls) or the quantity (credit ceilings) of bank borrowing and lending operations. There has been a degree of liberalisation in this area however. For example limits on lending rates were removed in 2004 and 2013 leaving the ceiling deposit rate as the only remaining regulated interest rate.</td>
</tr>
</tbody>
</table>

*Notes: Details for Table 11 were sourced from Frankel (2006), PBOC website, Bell & Feng (2013) Chen et al (2011) Geiger (2006, 2008) and author’s research.*
Chapter 5 is structured as follows. Section 5.2 reviews the Literature on the Taylor rule, the asymmetry of monetary policy reactions and on monetary policy in China. Section 5.3 gives a brief overview of the data and methodology. Section 5.4 presents the estimations and results and finally Section 5.5 concludes.

5.2 Literature Review

The Taylor (1993,1995) rule has been used for many years to examine monetary policy in advanced economies such as the US (Bernanke 2010) (Taylor 2009), The UK (Clarida et al 1999) (McCallum 2000) and the Euro area (Peersman & Smets 1999), (Gerlach-Kristen 2003). In its most common and basic form, the Taylor rule links monetary policy rates dynamically to the deviation of inflation from its target rate and output (or unemployment) from its natural level.

In more recent studies, academics and policy makers have focused on the asymmetry and non-linearity in monetary policy reactions. A central bank may respond differently to deviations of aggregates from their targets depending on factors such as the current phase of the business cycle (Castro 2008). Therefore, it would be more appropriate to model either a structural change or a non-linear type Taylor rule to explain the behaviour of monetary policy. Kim & Nelson (2006) employ a time-varying parameter model to examine US monetary policy since the 1950’s and found that the reaction was indeed unstable. Davig & Leeper (2007) use a similar technique to the one employed in this chapter by specifying that the reaction of coefficients in the monetary policy rule evolve according to a Markov process. Dolado et al (2005) and Surico (2007a, 2007b) have shown evidence that central banks respond differently to deviations of inflation and output from their target levels. Hamilton (1989) also makes the point that inflation and output gaps tend to have an asymmetric adjustment to the business cycle. For example, recessions tend to be sharp, while recoveries are longer and smoother. Inflation on the other hand usually increases more rapidly than it decreases. Using a regime switching Taylor rule for the Euro area, Markov (2012) finds that the main ECB policy rate switched between two regimes. The first regime emphasised stabilising the economic outlook of the Euro area, while the second, more aggressive regime, put a greater emphasis on real output growth expectations. Murray et al (2013) estimate a Taylor rule with endogenous Markov switching coefficients and variance for the US to correspond with the tenure of various Federal Reserve Chairmen. They found that while the
Federal Reserve consistently adhered to the Taylor rule before 1973 and after 1984, it followed the Taylor rule from 1975-1979 and did not follow the Taylor rule from 1980-1984. Castro (2008) examines if major central banks are following a linear or nonlinear (augmented) Taylor rule. The author finds that the ECB and the Bank of England tend to follow a nonlinear Taylor rule but the same is not true for the Federal Reserve. Hofmann & Bogdanova (2012) also state that there has been a symmetric reaction of monetary policy to the different stages of the financial cycle in core advanced countries.

The Taylor rule has also become increasingly popular as a gauge for assessment of emerging market economies (EME’s). Taylor (2008) himself states that the use of monetary policy rules in EME’s has many of the same benefits that have been found in research and in practice in developed countries. He adds the caveat, however, that market conditions in emerging market economies may require modifications of the typical policy rules that have been recommended with more developed financial markets in mind. While the focus of nonlinear monetary policy rule models have been taken by the US, the UK and the Euro area, there have been fewer studies of the asymmetric effects of monetary policy in emerging markets such as China. This is surprising as emerging economies are often characterised by ongoing reforms, political and economic changes, market liberalisation etc. which would make standard linear estimations such as OLS inappropriate for analysing monetary policy. Jawadi et al (2011) argue that for emerging markets, a nonlinear Taylor rule may give a more realistic description of the response of the monetary authority to economic development as it allows the analysis of asymmetric, discontinuous and time varying monetary policy reaction. Although many studies have noted that interest rates in the Chinese economy have played a minor role (for example Laurens & Maino 2007, Mehrotra 2007 and Koivu 2009), Wang & Handa (2007) find that the PBOC followed a Taylor type rule for the interest rate with the aim of inflation targeting and output smoothing during their estimation period of 1993-2003. Burdekin & Silkos (2008) examine monetary policy since 1990 using a McCallum type rule and find that the PBOC’s rate is responsive to both the output gap and external pressures. The authors argue that Chinese inflation and monetary policy outcomes can be satisfactorily modelled using standard empirical techniques and are not just a figment of China-specific ‘structural’ factors. Using data from 1994-2006, Li & Wang (2010) find that the Taylor rule is unstable in China. The authors claim that there is less correlation found between the

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85 The McCallum rule was proposed by Bennett McCallum of Carnegie Mellon University. The McCallum rule targets nominal GDP by setting the growth rate of the money supply.
interest rate and the output gap and that the PBOC focuses more on the inflation target than economic growth. Kong (2008) compares four kinds of monetary policy rules for China, including a Taylor and McCallum rule. The author finds that these models can describe the Chinese monetary policy stance in some degree and that Taylor rules are better than McCallum rules in evaluating monetary policy performance. In a more recent paper, Fernald et al (2014) make the very interesting finding that China’s monetary policy transition mechanism is closer to those of Western economies than previously realized.

Early work in the area of the asymmetry of the Chinese monetary policy rule was carried out by Lu & Shu (2002). The authors divided their entire sample using pre specified breakpoints. As Wang & Zhang (2014) point out however, the pre-specification of breakpoints in this manner is arbitrary and often suffers from poor model specification. Chen & Huo (2009) is one of few papers to tackle the issue of asymmetry and instability in the Chinese Taylor rule by estimating a model with drifting coefficients. The authors however fail to account for the role of qualitative instruments such as window guidance which is believed to play a very important role in Chinese monetary policy framework (Goodfriend & Prasard 2007). Studying a modified Chinese Taylor’s rule with money supply growth rate as the intermediate target, the authors do find however that there were two structural changes in the Chinese monetary policy rule, which take the form of discrete jumps rather than continuous adjustments. In their concluding remarks, the authors state that it may be better to use the Markov regime switching model to estimate the Chinese monetary policy rule. In a more recent paper, which perhaps is most similar in approach to this chapter, Zheng et al (2012) found that China's monetary policy can be well characterized by a two-regime forward-looking Taylor rule. They find that in the first regime, the People's Bank of China targets inflation, but does not focuses on the output gap; while in the second regime the central bank targets the output gap and the policy rule is not characterised by a stable framework. Based on the relatively scarce literature, Ma (2014) has pointed out that there are major gaps waiting to be filled in the study of China's monetary policy. For example, the author mentions the existing studies that investigate China's monetary policy have implicitly assumed a price rule, especially a Taylor-type interest rate rule. This may not be appropriate to the Chinese case for the reasons mentioned in Section 5.1 of this chapter. The lack of accountability of nonlinearities is also mentioned by the author.
The issue of asymmetry and non-linearity in monetary policy rule estimations is not just a China specific one. Many transition and emerging market economies experience structural breaks and nonlinearities when it comes to the monetary policy reactions of its central banks as they react to the ever changing conditions of the macro economy. From the perspective of a typical transition economy, some important features of monetary policy in transition, such as shifting preferences and nonlinearities of policymakers' choices, have been largely ignored in the existing literature. However, as noted by Hamilton (1989) and Surico (2007a), central banks may have asymmetric preferences in reality, which gives rise to the existence of a nonlinear monetary policy reaction function. Therefore, it is important to examine closely the specific preferences and policy’s adopted by these central banks in emerging market economies.

5.3 Methodology & Data

5.3.1 Methodology


\[ i_t = \bar{r}_t + \pi_t + b(\pi_t - \pi^*_t) + c(\bar{y}_t) \]  
\[ \text{(23.1)} \]

Which can be simplified to

\[ i_t = a + (1 + b)\pi_t + c(\bar{y}_t) \]  
\[ \text{(23.2)} \]

In this equation, \( i_t \) represents the nominal short term interest rate, \( \bar{r} \) is the equilibrium level of the real interest rate, \( \pi_t \) is the inflation rate, \( \pi^* \) is the target inflation rate and finally \( \bar{y}_t \) is the deviation of output from its natural level, i.e., the output gap. Taylor (1993) and later Woodford (2001) state that since the real interest rate drives private decisions, the size of the inflation coefficient, \( b \), needs to ensure that the nominal interest rate is raised enough to increase the real interest rate as a response to a rise in the inflation. This so called “Taylor principle” implies that \( b \) should be greater than 1. On the other hand, if \( b \) is less than 1 it indicates an accommodative behaviour on the part of the monetary authority to inflation which may result in self-reinforcing inflation. In parallel, the coefficient of output gap, \( c \), should be positive. The suitability of the Taylor rule of the form in Equation 23.1 and 23.2
can be tested empirically for China using the following interest rate backward-looking Taylor monetary reaction function (similar to that used in Girardin et al 2014) which also includes the exchange rate as a monetary policy target variable;

\[ i_t = a + b(\pi_{t-1} - \pi_t^*) + c(\ddot{y}_{t-1}) + d\Delta e_r + \epsilon_t \]  

(24)

In the above equation, \( i_t \) is the PBOC lending rate as used in Chapter 4 \((\pi_{t-1} - \pi_t^*)\)is the CPI inflation rate minus a target level of inflation, \( \ddot{y}_t \) is China’s output gap and finally \( \Delta e_r \) is changes in China’s nominal effective exchange rate. The Taylor rule (even in this augmented form) was however originally modelled for the US economy. While it has been used extensively for other developed economies, it may not be appropriate in the Chinese case. While Xie & Xiong (2003) state that the Taylor rule can provide a useful benchmark for measuring the stance of monetary policy in emerging economies such as China, the lack of studies in the area points to some difficulty in carrying out such research. Firstly, monetary policy changes in both emerging and transition economies can lack consistency and credibility, often when the economy is undergoing an extensive process of reform, with many emerging markets undertaking major market oriented reform. Chapter 2 (page 13) has discussed the general reforms and institutional changes that the Chinese economy has experienced while Section 5.2.1 of this chapter has briefly discussed the vast amount of reform that the Chinese banking system experienced over the last thirty years. There is also the reliance of intermediate targets as well as the use of a battery of different instruments, which would ultimately make the interest rate an ineffective measure of the PBOC’s monetary policy stance. While the majority of emerging market economies have adopted explicit inflation targeting regimes, China would seem to be an exception to this and no explicit inflation targeting regime has ever been announced by the PBOC (Hutchinson et al 2013). Instead, China operates a pegged exchange rate regime which is then supported by capital controls. This adds to the problem of modelling monetary policy reactions in China. Financial markets in emerging economies are also often underdeveloped and interest rates are often distorted by the monetary authority (Xie & Xiong 2003). China is no different and it is widely accepted that the PBOC directly controls commercial bank decisions.

Another issue which arises in the Chinese case is the problem of structural breaks, instability or non-linearity which can arise in a monetary policy reaction function. This non-linearity can arise from both the preference function of the Chinese authorities and the
structure of the Chinese economy (Girardin et al 2014). Due to these issues with Chinese economic data, standard constant parameter models such as traditional Taylor rules or McCallum rules would not adequately define the dynamics. As pointed out by Ma (2014), it is typical for emerging economies to experience structural change during periods of financial and economic reform which will ultimately lead to regime changes in monetary policy. Most of the literature in this area has focused on nonlinear price rules or quantity rules but very few have examined nonlinearities in the context of a calculated monetary policy index which replicates the monetary stance of a central bank. With these arguments in mind this chapter models an augmented Taylor rule as the linear benchmark as;

$$\text{MPI}_t = a - b(\pi_{t-1} - \pi_t^*) - c(\bar{y}_{t-1}) - d\Delta er_t + \epsilon_t$$  \hspace{1cm} (25)

As in Equation 24 \((\pi_t - \pi_t^*)\) is the deviation of inflation from its target, \((\bar{y}_t)\) is the deviation of output from its natural or potential level and \(\Delta er_t\) is changes in the nominal exchange rate of the Renminbi. Notice that \(i_t\) has been replaced with the monetary policy index, \(\text{MPI}_t\). This variable is intended to represent the quantitative and qualitative measures available to the People’s Bank of China (PBOC). While many monetary policy rules for China include a representation of changes in M2 as an intermediate target, this is not included in the monetary policy rule as the monetary policy index is estimated using changes in the money supply (see Chapter 4) and therefore would ultimately provide us with misleading or spurious results due to problems such as autocorrelation and heteroskedasticity. Another important point to note is the sign of the coefficients. The nature of the MPI’s calculation means that an increase in the index corresponds to expansionary monetary policy and a decrease to a contractionary policy. Therefore the expected signs will be the opposite of that as observed by standard theory.

5.3.2 Data

The estimations in this chapter were calculated using quarterly data from 1994Q1 to 2014Q3 as the Chinese government began to publish inflation targets for the first time in this year as part of their reform of the banking and financial sector. As in Chapters 3 and 4, adjustments for seasonality are made where appropriate. Figure 22 shows the plots all of the variables used in the estimations while Table 12 reports the results of the Augmented Dickey Fuller (ADF)

---

86 We can consider \(\epsilon_t\) in this equation to represent a zero mean error term that captures deviations from the monetary policy rule.
Test. All of the variables with the exception of the lending rate pass the test for integration of order zero (I- (0)). Therefore, the first differences of this variable is used. The data for the monetary policy index (MPI) was sourced from Egan & Leddin (2014) and is the same data used for the estimations of the IS curve in Chapter 4. This index was extracted using all the relevant monetary policy variables through a Kalman filter approach. Official quarterly inflation data is available from the National Bureau of Statistics (NBS) of China. The inflation target data was sourced from a combination of Kong (2008) and targets for CPI inflation mentioned in various publications of the ‘Report on the Implementation of the “YEAR” Plan for National Economic & Social Development and on the “YEAR+1” Draft Plan National Economic & Social Development’. Every year, the National People’s Congress (NPC)\(^{87}\), holds an annual plenary session. For example, the incumbent 12\(^{th}\) National People’s Conference are scheduled to meet five times, in March of every year from 2013-2018. At these sessions, the National Development & Reform Commission (a macroeconomic management agency under the Chinese State Council, which has broad administrative control over the Chinese economy), submit a report which includes economic updates, forecast and targets including the inflation rate.

**Figure 22 – All Relevant Variables for Chapter 4, 1994Q1-2014Q3**

- CPI Inflation
- Inflation Target
- Output Gap
- Changes in NEER
- Changes in M2
- Monetary Policy Index (MPI)
- Change in Lending Rate
- Lending Rate
- MPI

Source: IMF IFS, Oxford Economics, NBS & Author’s calculations.

\(^{87}\) The National People’s Congress (NPC) is the supreme organ of state power and the national legislature in China.
For the output gap, the estimations use the same variable as in *Chapters 3 & 4 (see Appendix B, page 134)*. This is available from the *Oxford Economics Global Economic Databank*. For the exchange rate, the nominal exchange rate against the US dollar is included since the RMB is heavily managed and any change in its parity is likely to affect the monetary policy stance. This quarterly data is available from the IMF IFS. As mentioned in previous chapters, the RMB exchange rate has received a great deal of attention both in the economic literature and in the media. Academics such as Koivu (2009) argue that the foundation of Chinese monetary policy has been a fixed exchange rate, while politicians and policy makers in the US claim that China intentionally suppresses the value of the RMB through massive market intervention to raise the competitiveness of its exports. The exchange rate in this chapter is again defined so that an increase stands for appreciation of the RMB.

| Table 12– Monetary Policy Rule Unit Root Test (Augmented Dickey-Fuller) |
|---------------------------------|-------|-------|-------|-------|-------|
| Variable                        | 1 lag | 2 lags | 3 lags | 4 lags | 5 lags |
| Output Gap                      | -2.60*** (0.00) | -2.35 * (0.02) | -2.04** (0.04) | -2.26** (0.02) | -2.36** (0.02) |
| Inflation Target                | -3.88*** (0.00) | -5.55*** (0.00) | -7.77*** (0.00) | -3.78 ** (0.01) | -3.33 ** (0.02) |
| Interest Rate (Lending)         | -1.35 (0.60) | -1.40 (0.58) | -1.42 (0.57) | -1.33 (0.61) | -1.47 (0.54) |
| Δ Interest Rate (Lending)       | -4.63*** (0.00) | -4.08*** (0.00) | -4.07*** (0.00) | -3.20** (0.02) | -3.22** (0.02) |
| Monetary Policy Index           | -5.28*** (0.00) | -4.53*** (0.00) | -4.77*** (0.00) | -3.09** (0.03) | -2.6* (0.09) |
| Δ in Exchange Rate              | -4.99*** (0.00) | -6.36*** (0.00) | -9.71*** (0.00) | -2.80* (0.06) | -4.44 (0.00) |

1% and 5% P-values are -3.52 and -2.90 for test with a constant. Rejection of the unit root hypothesis at the 10, 5 & 1% level is indicated with *, ** & ***. P-values are in parenthesis.
5.4 Estimations

5.4.1 Standard OLS Estimations

*Interest Rate (Lending)*

The standard OLS Taylor rule estimation (*Equation 24*) can be seen in *Table 13*. The results are not particularly compelling. Both the deviation in inflation and output from the target and potential level respectively are only significant at the 10% level and even then, the coefficients are small. The sign of the inflation gap is incorrectly negatively signed. The change in the exchange rate also does not have a significant bearing on the dependent variable. Furthermore, the $R^2$ is low a 0.1 suggesting that this specification is a poor fit to model the PBOC’s monetary policy reaction to deviations in their target levels. The equation, however does appear to be stable as the $SupF$ test fails to detect the presence of structural breaks over the time period. These results would reiterate the arguments of He & Pauwels (2008), Xiong (2012) and Girardin *et al* (2014) who all infer that a single interest rate rule would not appropriately represent the monetary policy reactions of the PBOC.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Interest Rate (24)</th>
<th>Monetary Policy Index (25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.01 (0.01)</td>
<td>-0.01 (0.01)</td>
</tr>
<tr>
<td>Inflation Gap</td>
<td>0.03* (0.02)</td>
<td>0.11* (0.07)</td>
</tr>
<tr>
<td>Output Gap</td>
<td>-0.04* (0.02)</td>
<td>-0.20** (0.09)</td>
</tr>
<tr>
<td>Δ in Exchange Rate</td>
<td>0.01 (0.01)</td>
<td>0.03 (0.02)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.1</td>
<td>0.17</td>
</tr>
<tr>
<td>DW Statistic</td>
<td>1.4</td>
<td>1.7</td>
</tr>
<tr>
<td>$SupF$ Stat</td>
<td>14.8 (no break)</td>
<td>28.0*** (2009Q1)</td>
</tr>
</tbody>
</table>

*Notes:* ***, ** and * denotes significance at the 1, 5 and 10% respectively. HAC standard errors are in parenthesis.
Monetary Policy Index (MPI)

Using the same standard OLS estimation technique, we can examine if the monetary policy index (MPI) improves on the specification of China’s monetary policy rule estimation. This index contains a weighted average of the policy instruments that are used by the PBOC. It includes both quantitative and qualitative instruments. The results of this estimation can be seen in the right hand column of Table 13. The results of these estimations are also not very compelling. The reaction of the policy index to a deviation in inflation from its target level is again only significant at the 10% level and its coefficient is small at 0.11. The sign on the coefficient is also incorrect. The exchange rate is once again insignificant, however the R$^2$ is marginally higher than in our previous model at 0.17. The deviation of output from its potential level is significant and correctly signed\textsuperscript{88}. This would suggest that as output deviated above (below) its potential level, the PBOC would respond with contractionary (expansionary) policy. The magnitude of this relationship can be examined by estimating the effect of 1% S.D. change in the output gap to the policy index\textsuperscript{89}. A 1% S.D. increase in the output gap leads to a 0.26% decrease in the monetary policy index\textsuperscript{90}. While this relationship seems fairly strong, it is important to point out that there is strong evidence of structural instability as represented by the strong and highly significant value of the SupF statistic, which indicates a structural break in 2009Q1. This break would correspond to the stimulus package which was announced by the PBOC in the aftermath of the Global Financial Crisis. This will be discussed in greater detail as the chapter progresses.

5.4.2 Multiple Breakpoint Model

Given the presence of a structural break in the estimation, the multiple breakpoint model developed by Bai & Perron (1998), (2003) is adopted. This is a linear regression model that is subject to structural change. A key feature of this technique is that it allows us to test for multiple breaks at unknown dates. Full details of this procedure and its estimation are available in Chapter 3 (page 52) and in Appendix A (page 129). Applying this procedure to the augmented IS curve with the calculated policy index, this gives us the following IS curve equation with $m$ breaks;

\textsuperscript{88} It is once again important to point out that due to nature of the MPI’s calculation, an increase (decrease) in the index corresponds to expansionary (contractionary) monetary policy.
\textsuperscript{89} Details of this estimation procedure can be found in Chapter 3 (page 54).
\textsuperscript{90} Summary statistics for this chapter can be found in Appendix G.
$$MPI_t = a_1 - b_1(\pi_{t-1} - \pi^*_t) - c_1(\bar{y}_{t-1}) - d_1 \Delta er_t + \epsilon_t \quad t = 1, \ldots, T_1$$ \hspace{1cm} (26)

$$MPI_t = a_m - b_m(\pi_{t-1} - \pi^*_t) - c_m(\bar{y}_{t-1}) - d_m \Delta er_t + \epsilon_t \quad t = T_{m+1}, \ldots, T$$ \hspace{1cm} (27)

Table 14 presents the result of the multiple breakpoint estimations.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.08***</td>
<td>-0.15***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Inflation Gap</td>
<td>-0.07</td>
<td>0.15*</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>Output Gap</td>
<td>1.06**</td>
<td>-0.29***</td>
</tr>
<tr>
<td></td>
<td>(0.40)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>Δ in Exchange Rate</td>
<td>0.23***</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.02)</td>
</tr>
</tbody>
</table>

Notes: ***, ** and * denotes significance at the 1, 5 and 10% respectively. HAC standard errors are in parenthesis

As previously mentioned in Section 5.4.2, the SupF test detects a breakpoint at 2009Q1\(^91\). In Period 1 (1994Q2-2009Q1), the inflation gap, while correctly signed is small and insignificant, indicating that the PBOC was very accommodative of inflationary pressure. The coefficient on the output gap is high in both significance and magnitude. However, the sign on this coefficient is incorrectly found to be positive which would indicate that the PBOC actually undertook paradoxical monetary policy responses in this period. While this logic seems counter intuitive, the coefficient on the exchange rate may provide an explanation for this. Changes in the nominal effective exchange rate are highly significant with a coefficient of 0.23. A 1% S.D. in the exchange rate leads to a very strong change of 2.1% in the monetary policy index. This suggests that the PBOC responded very strongly to

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\(^91\) Although the multiple breakpoint model is designed to pick up several breaks, only one is detected at 2009Q1.
any deviations in the level of exchange rate during this period. This is an interesting finding as it suggests that the PBOC’s preference for controlling the movements in the exchange rate may have limited its appropriate response to deviations in the level of output. This reiterates the point made by Prasard (2009), that monetary policy independence and effectiveness is a mirage if the central bank is mandated to obtain an exchange rate objective. This could also be seen as an example of the impossibly trinity. The impossible trinity, which states that it is not possible to have full capital mobility, a fixed exchange rate and independent monetary policy, is widely believed to be a major issue currently facing the Chinese economy (See Chapters 2, page 36 and Chapter 6, page 123-124).

The period after the breakpoint, Period 2 (2009Q2-2014Q3), describes a very different monetary policy reaction on the part of the PBOC. Again, the inflation gap does not appear to be an important factor in the monetary policy reaction. While the coefficient is this time significant (if only at the 10% level), it is incorrectly signed. The exchange rate variable has gone from being highly significant in Period 1 to insignificant. What is perhaps most interesting is that the coefficient on the output gap is now highly significant and correctly signed. A 1% S.D. in the output gap leads to a 0.51% change in the monetary policy index. This indicates that the priority of the PBOC shifted away from the exchange rate in 2009 and towards maintaining output at a level close to its potential.

From the results of the multiple breakpoint estimation, we can make several inferences. As in the two OLS estimations, the inflation gap does not appear to play an important factor in the monetary policy response of the PBOC across the entire estimation period. This is in line with Mehrotra & Sanchez-Feng (2010) who find the same result over a similar period (1994-2008). The authors of this paper argue however that as the inflation gap is mostly negative in their estimation period, inflationary pressure may not have been a major concern for the PBOC. The breakpoint date recognised by the $SupF$ test is 2009Q1, after which there was a definite change in the monetary policy reaction function. At first glance, one could argue that this structural break points to a more traditional central bank reaction function that targets the level of output and puts less emphasis on the exchange rate and may even point to a more independent and autonomous monetary authority. This may not be the case however. First of all, in early 2009, the size of China’s foreign exchange intervention and reserve accumulation fell sharply as capital inflows slowed and the trade surplus narrowed due to the effects of the Global Financial Crisis (see Figure 8 page 32 and Figure

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92 This can be confirmed by examining the summary statistics of inflation in Appendix G.
This meant that maintaining the RMB at a certain level was no longer the main focus of the monetary policy reaction. Late 2008 and early 2009 also represents an important event in China’s macro economy. In September 2008, it was announced that ¥4 trillion (around €580 billion) would be spent on upgrading infrastructure, raising rural incomes via land reforms and other social projects such as affordable housing and environmental improvements. This event may explain the increase in the policy index to the level of output as seen in Period 2. Despite being labelled a “fiscal” stimulus package, in practice, this stimulus package was closely linked to monetary easing policies. The plan from the very outset was that this package would be financed primarily by increased bank lending rather than through government budget (Lardy 2010). This again highlights the hierarchical nature of the Chinese financial and banking system. Unlike traditional independent central banks, the PBOC’s role often consists of being less involved in directly providing and absorbing liquidity to the money market and more in acting as a transmission belt between the government and the commercial banks so as to influence growth and inflation (Riedel et al 2007).

5.4.3 Markov Switching Model

By fitting the linear monetary policy rule equation to the Markov switching framework, we get:

\[ MPI_t = a_{st} - b_{st} (\pi_t - \pi_t^*) - c_{st} (y_t - y_t^*) + d_{st} \Delta e_t^* + \epsilon_{tst} \]  

(28)

Table 15 (page 111) presents the results of the Markov switching estimations and Figure 23 plots the states recognised by the model with the three monetary policy targets. The model characterises the monetary policy reaction into two different states – State 1 and State 2. In State 1, as in the previous estimations of this chapter, the inflation gap seems to play no significant role in the monetary policy reaction of the PBOC. The coefficient is only significant at the 10% level and is incorrectly signed. Changes in the exchange are also not statistically significant in State 1. The output gap on the other hand is highly significant with a coefficient of -0.54. A 1% S.D. in the output gap results in a 0.55% deviation in the monetary policy index. The summary statistics in Appendix G indicate that State 1 is, for the most part, characterised by a negative output gap (with a mean of -0.5%) and a positive or appreciating exchange rate (with a mean of 3.7%).
In *State 2*, the inflation gap is again insignificant and incorrectly signed. The output gap has now switched from being significant and correctly signed to being insignificant and incorrectly signed. What is perhaps most interesting is that the exchange rate is now highly significant with a coefficient of 0.05. A 1% S.D. in the exchange rate results in a 0.37% deviation in the monetary policy index. The summary statistics in Appendix G show that *State 2* is characterised by a negative output gap (with a mean of -0.9%) and a negative or depreciating exchange rate (with a mean of -0.2%).

The results of the MS estimations paint an interesting picture about the monetary policy reaction function in China. While possessing different characteristics and allowing for more dynamic estimations than the multiple breakpoint model\(^93\), the results of the MS model actually seem to compliment the findings of Section 5.4.2. First of all, the PBOC seem to have been very accommodative of inflation over the estimation period as the inflation gap was not found to have any significant effect on the monetary policy index across either state. This again can be attributed to the fact that the inflation gap was predominately negative over the estimation period. The output gap is only significant in *State 1*, when the exchange rate is appreciating and therefore not targeted by the PBOC’s basket of policy instruments. On the other hand, in *State 2* the output gap is no longer significant. During this state, changes in the exchange rate are highly significant and, on average, the exchange rate is depreciating. As it is almost universally accepted that the RMB was undervalued over the entire estimation period\(^94\), any depreciation of the RMB could possibly be viewed as an intervention by the PBOC to maintain the RMB at a desired level. When the exchange rate is “managed” in this way, adjustments in terms of trade or exchange rate cannot be used to mitigate the impact of external shocks. Under this regime, increases in the cost of sterilization following a sudden decline in foreign interest rates further constrain the central bank’s ability to stabilize the economy (Chang *et al* 2014).

Based on the results of the estimations in this section, it is quite reasonable to suggest that when the PBOC do not intervene heavily in the foreign exchange market and allow the RMB to appreciate it retains its ability to stabilise the level of output through its monetary policy instruments. However, when the PBOC intervene in the foreign exchange market to

\(^93\) For differences and similarities between both the Markov switching and multiple breakpoint technique, see *Appendix A*, page 129.

maintain the RMB at a desired level, they surrender this stabilisation channel. This loss is possibly linked to the cost of the sterilisation process (see Chapter 2, page 34). The surrender of an effective output stabilisation channel could have a profound effect on the stability of the Chinese economy, particularly as it enters a new era of reform intended on introducing a more balance domestic led growth model. The current policy could cause the PBOC to react in an inappropriate or counterproductive manner to certain shocks to aggregate demand due to the constraints caused by the exchange rate policy. This can be examined further by looking at the state coefficients and summary statistics in Table 15 and Appendix G respectively. In State 1, the PBOC actually operated a paradoxical monetary policy response i.e. adopted contractionary monetary policy when output was below potential and the economy was operating below capacity, in favour of maintaining the exchange rate at the desired level. Again, this trade-off that the PBOC face between maintaining a stable level of output and maintaining the exchange rate at a desired level is a classic example of the impossible trinity problem which has been a common theme throughout this thesis.

### Table 15 – Monetary Policy Rule with Markov Switching Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>State 1</th>
<th>State 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable: Estimated Monetary Policy Index (MPI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.01***</td>
<td>-0.01*</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Inflation Gap</td>
<td>0.29*</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.17)</td>
<td>(0.16)</td>
</tr>
<tr>
<td>Output Gap</td>
<td>-0.54***</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>(0.19)</td>
<td>(0.13)</td>
</tr>
<tr>
<td>Δ in Exchange Rate</td>
<td>-0.01</td>
<td>0.05***</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>$p_{11}$</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>$p_{12}$</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>$p_{21}$</td>
<td></td>
<td>0.28</td>
</tr>
<tr>
<td>$p_{22}$</td>
<td></td>
<td>0.72</td>
</tr>
<tr>
<td>Duration of State</td>
<td>2.7 quarters</td>
<td>3.5 quarters</td>
</tr>
</tbody>
</table>

Notes: ***,** and * denotes significance at the 1, 5 and 10% respectively. Standard errors are in parenthesis
Figure 23 – Inflation Target, Output Gap & Exchange Rate with Regime Classification

(a) Inflation Target

(b) Output Gap

(c) Changes in NEER

Source: IMF IFS, NBS, National People’s Congress Oxford Economics & Author’s Calculations
5.5 Conclusion

The motivation of this chapter was to examine the monetary policy reaction in China by estimating a selection of augmented “Taylor type” rules. The standard OLS estimation with the lending interest rate set by the PBOC as the dependent variable seems to be a very poor fit to the monetary policy reaction function of the PBOC. This result is not surprising and seems to support the arguments originally made in Chapter 4, namely that the PBOC use a mixture of quantitative and qualitative monetary policy instruments. The inclusion of the monetary policy index as the dependent variable improves the specification slightly, but this estimation was found to contain structural breaks.

Therefore, both a linear model that allows for multiple structural breaks and a non-linear model which allows dynamic switching between different states are employed to the augmented monetary policy rule. These two different techniques provide similar results. First of all, both estimations indicate that the PBOC were accommodative of inflation over the entire estimation period of 1994-2014. This is in line with Mehrotra & Sanchez-Feng (2010) who argue that as the inflation gap has been mostly negative over the last twenty years, inflationary pressure has not been of huge concern to the PBOC.

The multiple breakpoint model detects a breakpoint at 2009Q2. Prior to this breakpoint (i.e. 1994Q2-2009Q1), the PBOC seemed to adopt counterintuitive monetary policy responses i.e. they expanded (contracted) monetary policy when output was operating above (below) potential. While this policy seems illogical, the highly significant reaction of the policy index to changes in the NEER in the same period seem to indicate that the PBOC’s exchange rate policy may have prevented the appropriate policy response to deviations in output from its potential level. After the breakpoint (2009Q2-2014Q4) this dynamic changed however. The exchange rate no longer had a significant effect on the MPI while changes in the level of output did. This is not attributed to the increased independence of the PBOC but instead to the slowdown in capital inflows as a result of the financial crisis and the fiscal stimulus package introduced in 2008 by the state council which was strongly linked to monetary policy.

The results of the Markov switching estimations add another dimension to the analysis of China’s monetary policy reaction function. Despite applying a very different technique that allows switching between different states, the MS results tell a similar story to
that of the multiple breakpoint estimations. In *State 1* of the model, the PBOC reacts strongly and appropriately to deviations in output from its potential level. Changes in the exchange rate do not have a significant effect on the monetary policy index in this state. In *State 2*, the PBOC no longer reacts appropriately to the output gap but instead responds to deviations in the nominal effective exchange rate. What is most interesting about the results of the MS estimations is that in *State 1*, the RMB appreciates against its basket of trading currencies while in *State 2* it depreciates. As the RMB was considered undervalued throughout the estimation period, a depreciation in its value can be seen as intervention on behalf of the PBOC. The results therefore may point to the fact that the PBOC lose the monetary policy transmission channel in terms of output stabilisation during periods when they intervene in the foreign exchange market to maintain the exchange rate at a desired level. This argument points once again to the impossible trinity problem.
Chapter 6. Conclusion

6.1 Thesis Overview

This thesis has used quarterly time series data to explore and identify the determinants of inflation, the transmission mechanism of monetary policy, and the reactions of monetary policy to deviations in economic targets in China during the reform era. The study covers a period that has been characterised by a redefined economic structure, financial liberalisation, increased openness and reform, not to mention unprecedented growth and development.

While the use of standard linear macroeconomic models have been used to examine the macroeconomic fluctuations and dynamics of economies like the US, the UK and The Euro Area, the unique characteristics of the Chinese economy, along with the changes and reforms that have characterised the economic and political environment over the last three decades, mean standard models are often not well suited to Chinese macroeconomic data. Therefore, this thesis attempts to model the Chinese macro economy using an augmented versions of a New Keynesian (NK) model. Three major modifications were identified as being imperative to estimating this type of canonical model for China - a transition economy which has changed from a centrally planned to a market structure. These modifications are summarised briefly below.

6.1.1 The Inclusion of the Exchange Rate in the NK model

In many emerging and transition economies where the interest rate channel is weak, the exchange rate channel often plays a significant role in propagating monetary shocks to output and prices. China, in particular, has relied heavily on its exchange rate for its macroeconomic development. This has been discussed in detail in Section 2.3.3 (page 29) and Chapter 3 (page 45) of this thesis. As the Peoples Bank of China (PBOC) has been more reluctant to use the interest rate as an operating target, instead setting intermediate targets for money supply growth and the exchange rate, it is crucial to examine what effect the RMB played in the PBOC’s monetary policy reactions and macroeconomic stability. Also, as the RMB was fixed to the USD for the majority of the estimation periods of this thesis, it is important to analyse the effect of the peg itself, the effect of the interventions to maintain the RMB at a certain level and the effect of sterilisations which followed.
6.1.2. Estimating a Monetary Policy Index (MPI)

Chapters 2, 4 and 5 have all alluded to the unconventional nature of the PBOC. China’s monetary authority has used a basket of different tools in the conduct of its monetary policy. These tools include quantitative tools such as interest rates, deposit rates, reserve requirement etc. as well as qualitative tools and other administrative measures (see Table 11, page 96 for an overview). Therefore, the single policy variable that appears in the standard IS curve and Taylor rule would not be an appropriate measure of the monetary policy stance of the PBOC. To resolve this issue, Chapter 4 (see pages 73-81), constructs a composite index of the monetary policy tools at the disposal of the PBOC. This is done by creating a weighted index of all the quantitative tools used as outlined in the Monetary Policy Instrument Framework\(^95\) of the People’s Bank of China. It also includes a created variable for qualitative instruments which would include actions such as window guidance, selective credit allowances and other instructive measurements. As these instruments are not directly observable, they are estimated through a Kalman filter in a State Space Model (SSM). By combining all of these instruments, this thesis creates a composite index of the tools available to the PBOC which may give a more accurate representation of the stance of the monetary authority than would be suggested by single policy variable.

6.1.3 Accounting for Non-Linearity, Asymmetry, Structural Breaks & Change

Any economy that transforms from a closed communist structure to an open economy in a relatively short period of time will experience a huge amount of structural change in the process. China is no exception to this. Prices have been liberalised, trade has increased extensively, companies have been privatised and the economy has been transformed from one that was centrally planned prior to a market economy in a relatively brief period. It has also experienced several economic shocks, some of which were related to policy measures to liberalise, reform and marketise the economy\(^96\). These events lead to breaks or “jumps” in time series data that make standard linear models unsuitable. Changes to the structure of an economy like this will causes breaks in datasets of macroeconomic variables which will ultimately lead standard linear models to under (or over) estimate any relationship between a

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\(^{96}\) For further details on China’s economic reform, please see Chapter 2, (page 13-18).
set of variables. These changes may also cause asymmetric responses of different variables to one another over time depending, for example, on the stage of the business cycle. Therefore, this thesis estimates an augmented version of the NK model in a framework that accounts for structural breaks, asymmetry and non-linearity. This is done by estimating the NK model equations using a linear model that allows for multiple structural breaks and a nonlinear Markov switching models which allows variables to switch between different states, thus capturing more dynamic patterns and relationships between the data.

Contribution

By making these modifications, this thesis aims to give a more accurate representation of China’s unique characteristics and therefore provide a better understanding of how macroeconomic variables interact in the world’s most dynamic economy. This is the key contribution of this research as it is the first, to our knowledge, to combine all three of the above mentioned “specifics” of the Chinese economy in a single study.

Research Question

Can we improve the understanding of Chinese macroeconomic dynamics using augmented versions of standard macro models? If so, what do the results of these estimations tell us about macroeconomic stability in China and the challenges that the PBOC face as a result of their unique approach to economic stabilization, particularly in with the future plans for economic reform and rebalancing?
6.2 Summary of Empirical Results

This section provides a summary of the empirical results of Chapters 3, 4 and 5. Table 16 provides a brief overview of the model specification, estimation period and overall findings.

Chapter 3. The Phillips Curve – Inflation Determination in China

Chapter 3 finds that the Chinese Phillips curve is not generated by a linear relationship and that a structural break is found in 1994Q1 - therefore making a standard linear model inappropriate for the estimation of Chinese inflation dynamics. What is interesting is that the break point corresponds to the adoption of the RMB/USD peg. The multiple breakpoint model finds that from 1988-1994, the deviations of output from its natural level had a significant effect on the inflation rate. The exchange rate does not affect inflation during this period. From 1994-2014 however, the exchange rate does have a significant effect on the inflation rate and the effect of deviations of output from its natural level to the price level has decreased substantially. Inflation persistence remained high during both periods. The non-linear Markov switching estimation of the Chinese Phillips curve made similar findings to that of the multiple breakpoint model. It found that China’s inflation process can be characterised by two states. In State 1, the inflation rate is responsive to the level of output and the exchange rate is insignificant. There is a change when the model switches to State 2 however, as the exchange rate becomes significant and the output gap becomes insignificant. This mirrors the results of the multiple breakpoint model and suggests a trade-off between China’s exchange rate policy and independent monetary policy. In simple terms, the PBOC lose control of the inflation adjustment mechanism through the output gap when the exchange rate is significant. What is perhaps most interesting about the findings of the breakpoint model and the Markov switching model is the shape of the Phillips curve. The estimations both suggest that the Chinese Phillips curve is concave. A concave Phillips curve is an upward sloping curve that flattens as output rises above its natural or potential level. The curve is steeper at levels of output below potential. A concave Phillips curve points to the declining sensitivity of inflation to the strength of the economy, and is often symptomatic of an economy where firms are not perfectly competitive.
<table>
<thead>
<tr>
<th>Model</th>
<th>Main Findings, Conclusions and Policy Options</th>
</tr>
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</table>
| Phillips Curve (1988Q1-2014Q3) | - The Chinese Phillips curve is not generated by a linear relationship  
- The output gaps effect on inflation has decrease substantially since 1994, which, interestingly, corresponds to the adoption of the dollar peg  
- The Chinese Phillips curve is characterised by a nonlinear relationship and the inflation/output relationship takes the form of a concave curve, attributed to the large number of monopolies in the Chinese economy  
- The People’s Bank of China (PBOC) should account for nonlinearities, asymmetries and structural breaks in both the modelling and forecasting of inflation dynamics |
| IS Curve (1991Q1-2014Q3)      | - There is a significant and stable link between the lending interest rate set by the PBOC and aggregate demand in the Chinese economy. This effect is small however  
- The constructed monetary policy index highlights the importance of qualitative instruments in Chinese monetary policy  
- Monetary policy is more effective when the economy is operating above potential (positive output gap) and less effective when operating below (negative output gap). This is indicative of the concave shape of the Phillips curve which was found in Chapter 3  
- It seem that China’s de facto fixed exchange rate regime may have constrained the effectiveness of monetary policy. |
| Monetary Policy Rule (1994Q1-2014Q3) | - A standard Taylor rule with a single policy variable such as the lending rate set by the PBOC is not an appropriate framework to examine Chinese monetary  
- The inflation gap was found to have no significant effect on monetary policy. This is attributed to the fact that the inflation gap was negative for the majority of the estimation period  
- Maintaining the RMB at a desired level would appear to have constrained the PBOC’s ability to stabilize the level of output through the use of its monetary policy actions in this period.  
- Results are concurrent with “the impossible trinity” problem |
Chapter 4 examines China’s monetary policy transmission channel by estimating three different Investment-Saving (IS) curves. The results of the standard single policy variable model show that, at odds with the majority of studies on the topic, there is a significant and stable link between the lending interest rate set by the PBOC and aggregate demand in the Chinese economy. This link however, is quite small. The chapter then constructs a monetary policy index based on the instruments, both quantitative and qualitative, at the disposal of the PBOC. The constructed index highlights the importance of qualitative instruments in the conduct of Chinese monetary policy. A standard OLS curve, with this policy index in place of the interest rate, is found to be unstable and there is evidence of the presence of structural breaks. What is interesting is that this break, like that in Chapter 3, is in 1994, which corresponds to the beginning of RMB/USD peg.

The results of the multiple breakpoint model confirm one break in the time series in 1994. The model states that from 1991-1994, the PBOC was able to influence the level of output through the use of their monetary policy instruments. From 1995-2014 however, the monetary policy actions of the PBOC have had only a minor effect. While this seems counter intuitive, due to the increased reform in the financial sector as well as measures which have promoted greater PBOC independence, this result is attributed to the trade-off between China’s exchange rate regime and independent monetary policy. The model suggests that while China’s de facto fixed exchange rate regime has served on one hand to insulate the Chinese economy from external demand shocks, it also constraint the effectiveness of monetary policy.

The results of the Markov switching estimations give another perspective into the monetary policy transmission channel in China. This model found strong evidence that monetary policy reactions have a more powerful effect on output when it is operating at or above potential. On the other hand, when output is operating below potential, the monetary policy actions of the PBOC have little or no effect on the real economy. Monetary policy that is more effective when the economy is stronger and less effective when weaker is indicative of the concave shape of the Phillips curve which is consistent with the results found in Chapter 3.
Chapter 5. A Monetary Policy Rule for China

Chapter 5 estimates an augmented version of a “Taylor type” monetary policy rule. This monetary rule contained the monetary policy index estimated in Chapter 4 as the policy instrument of the PBOC and also included changes in the nominal effective exchange rate as an intermediate target of the PBOC. The estimations first confirm that a standard Taylor rule with a single policy variable such as the lending rate set by the PBOC is not an appropriate framework to examine the Chinese monetary policy reaction. A standard OLS estimation with the policy index in place of the interest rate, while providing a better fit, was found to be unstable. Therefore, the multiple breakpoint model and Markov switching model was applied as in Chapters 3 and 4. The inflation gap was found to have no significant effect on the monetary policy actions of the PBOC across both models. This is attributed to the fact that the inflation gap was negative for the majority of the time period and, therefore, Chinese authorities could focus more on maintaining output at a desirable level.

The multiple breakpoint model indicates that there was a structural break in 2009. The model suggests that from 1994 to this period, the PBOC were not responsive to deviations in the output gap and in fact pursued a counter intuitive policy reaction. The exchange rate was highly significant in this period however. The cost of sterilising interventions to maintain the RMB at a desired level would appear to have constrained the PBOC’s ability to stabilize the level of output through the use of appropriate monetary policy actions in this period. These results bear the hallmarks of “the impossible trinity” problem which states that it is not possible to have full capital mobility, a fixed exchange rate and independent monetary policy.

The results of the Markov switching estimation while having the added advantage of being able to switch between different regimes, compliments those of the multiple breakpoint estimations. The MS model also suggests that the PBOC loses its ability to stabilize the economy through monetary policy actions at times when intervention in the foreign exchange market is undertaken to maintain the RMB at a desired level.
6.3 Policy Options & Recommendations

Below are a set of possible policy options and recommendations based on the empirical results of Chapters 3, 4 and 5.

Chapter 3. The Phillips Curve – Inflation Determination in China

The findings in Chapter 3 provide important policy recommendations. High levels of inflation persistence across all three models would appear to underline the need for clear and transparent signals on behalf of the PBOC in order to adequately anchor inflation expectations. Uncertainty regarding the inflation objectives of a central bank will usually cause inflation to exhibit a high degree of persistence. A more credible inflation target policy which is focused more on price rather than exchange rate stability would potentially reduce this persistence. Indeed, the Chinese exchange rate has long been a contentious issue for Chinese policy makers. The results of the estimations indicate that as changes in the exchange rate became more significant to the level of inflation, the deviation of output from its potential became less significant. This perhaps points to a recommendation of further flexibility of the RMB. Finally, there are important policy options relating to the concave nature of the inflation/output relationship. The estimations suggest that the cost of fighting inflation varies systematically depending on the strength of the economy. This would indicate that the lesson for the PBOC in terms of monetary policy would be to consider output cost and policy response on a case by case basis depending on the level of output in relation to potential. The PBOC would therefore benefit from policies that are more proactive in nature than suggested by traditional linear models.

Chapter 4. The IS Curve – Examining Monetary Policy Transmission in China.

The results of Chapter 4 seem to suggest that China’s exchange rate policy has restricted the effectiveness of the PBOC’s monetary policy response. This has also been discussed at length in Chapter 5. While there have been some significant developments in 2005 and 2008, a further liberalisation of the exchange rate regime would accommodate greater monetary policy independence and effectiveness. If monetary policy is less effective or even ineffective when output is operating below potential as our results suggest, then the PBOC will need to resort to alternative monetary policy tools to continue to achieve its goal of “maintaining economic growth”. This would also be aided by further reform of the
financial and banking sectors which may help reduce output volatility and allow for greater symmetry in the transmission of monetary policy.

Chapter 5. A Monetary Policy Rule for China

While the estimations in Chapter 5 by no means provide a definitive model of Chinese monetary policy, some constructive conclusions can still be drawn from the empirical results of the estimations. First of all, in agreement with Goodfriend & Prasad (2006), Goldstein & Lardy (2007) and Chang et al (2014), the results would suggest that China’s quasi-fixed exchange rate regime has the potential to restrain the PBOC from conducting independent and appropriate monetary policy. As the PBOC would have to increase the money supply to maintain the exchange rate at a desired level, it may cause them to avoid reacting to deviations in the output gap in an appropriate manner. This could ultimately lead to the Chinese economy being exposed to significant risk of macroeconomic instability. The main policy recommendation from the results of this chapter would seem to echo those outlined in the preceding two empirical chapters. The PBOC should be granted increased monetary policy independence to mitigate against the adverse effects of external shocks which would disrupt macroeconomic stability. This would be complimented by continued reform in the financial and banking sector in China and, perhaps most importantly, further flexibility of the RMB.

Overall Policy Recommendations

While the three empirical models97 in this thesis were estimated across different time periods98 and used unconventional and augmented versions of standard models, the policy implications from the individual chapters seem to complement each other and are, in fact, strikingly similar. The overarching conclusion and policy recommendations from the three empirical chapters involve further reform and liberalisation in both monetary and exchange rate policy. As long as China continues to place a higher priority on exchange rate stability than on using monetary policy as a tool for macroeconomic control, it would appear that their scope for an autonomous monetary policy is constrained. This is particularly important in light of the plans for rebalancing China’s growth model which was discussed in Chapter 1 and 2 (see for example pages 2, 13, 31 & 38). The empirical results of this thesis would seem

97 That is the Phillips curve, the IS curve and the monetary policy rule.
to suggest that while the Chinese economy has performed exceptionally since the reforms of 1978 were introduced, there are several possible fragilities and vulnerabilities that could affect Chinese economic growth and stability in the future. The results highlight monetary policy’s constraint due to exchange rate policy, asymmetric effects of monetary policy actions on output/inflation and high degrees of persistence to economic shocks. All of these serve only to undermine long-term economic stability in China.

There are interesting policy recommendations that can be drawn from the results of this thesis. First of all, a flexible and independent monetary policy oriented at domestic objectives is crucial for the future development of the Chinese economy. This thesis has discussed the “impossible trinity” of independent monetary policy, full capital mobility and a fixed exchange rate. While many authors have argued that China can avoid the “trilemma” problem thanks to its closed capital account, there is however great debate over the effectiveness of capital controls and many are of the opinion that capital controls merely alter the form of capital flows without altering their magnitude. If this is the case, the heavily managed RMB exchange rate implies that China imports its monetary policy and lacks control over local short-term interest rates (Ma & McCauley 2007). Also, Goodfriend & Prasard (2006) argue that this results in inadequate control of investment growth and inflationary/deflationary pressures. Therefore, to grant the PBOC operational monetary policy independence requires further flexibility of its exchange rate policy.

The thesis has shown that the maintenance of an exchange rate regime with limited flexibility exposes the economy to significant risks of macroeconomic instability. The adoption of a more flexible system would inevitably lead to further reform of the financial and banking sectors. The greater degree of independence and flexibility may lead to more transparent communication of monetary policy intentions on behalf of the PBOC to the public. This would be particularly important as China faces its next generation of reforms aimed at a more “stable, balanced, coordinated and sustainable” growth model. The smooth transmission to this new growth model has been of particular concern over the last five years as there has been great debate in China and among international commentators with regard to the “slowdown” the Chinese economy has experienced over the last few years. With GDP growth of 7.7% in 2014, the lowest in almost twenty-five years, many experts

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100 This phrase is adapted from a famous speech made by the Chinese Premier Wen Jiabao in March during the National People's Congress when he stated “The biggest problem with China's economy is that the growth is unstable, unbalanced, uncoordinated and unsustainable”
(including the IMF\textsuperscript{101}) have been debating whether the world’s second largest economy and the single largest driver of global growth for over a decade, might soon face a hard landing. What makes the situation perhaps even more perilous is that the lack of credibility and transparency in the Chinese financial sector serves only to impede the prospects of a soft landing. It would therefore seem that continued reform, liberalisation and transparency in the financial sector is more important than ever.

It is crucial however to realise in summary that any possible policy recommendations must be considered in the context of the China’s political environment. It is widely accepted (and has been discussed throughout this thesis, see for example pages 30, 36 &37) that the PBOC is not an independent and omnipotent monetary authority. All major decisions with regard to monetary and exchange rate policy and reforms must be approved by the State Council. Bell & Feng (2013) also point out that despite increased authority being shifted to the PBOC over the last decade or so, the State Council still see the banking and financial sector as one of its central concerns – both in relation to political stability and economic growth. Therefore, the governing party see this control as being extremely important and sensitive and is one that they have been very reluctant to relinquish. Therefore, the lack of complete monetary policy authority and autonomy can be viewed as a key challenge of the PBOC in responding effectively and appropriately to macroeconomic shocks in the future.

\textsuperscript{101} The IMF (2014b) for example state that without a change in the pattern of growth, the likelihood of a shock triggering financial disruption and/or a sharp slowdown will continue to rise. Overreliance on credit and capital accumulation to support growth would further weaken balance sheets and reduce investment efficiency. This would ultimately lead to a slowdown in growth, and put further pressure on corporate profits and the financial system. The more vulnerabilities accumulate, the more likely it is that a shock could trigger a negative feedback loop. Thus, although the near-term risk of a hard landing is low, it increases to medium over a medium-term perspective.
6.4 Limitations and Future Direction of the Research

While this thesis has provided a set constructive conclusions, there are also many limitations which need to be highlighted. These are outlined below.

Like any research on the Chinese macro economy, the path of this research has been interrupted on more than one occasion by the issue of data quality. There is substantial evidence that China’s economic data and statistics are less reliable than that of advanced economies. The issue of data quality has been discussed at length in Chapter 2. It has been suggested that improving the quality of macroeconomic data is an important prerequisite in successfully implementing financial reform and liberalisation. The thesis tries to overcome the obstacle of Chinese data quality by using many different time series from different sources and examining data for matching trends, jumps, breaks etc. This included correspondence with many different institutions and resources which specialise in Chinese data. I exchanged and compared data with experts in the field of Chinese macroeconomic data such as the OECD Asian Desk, Oxford Economics Chief China Economist and also the China Data Centre at the University of Michigan in an attempt to improve the quality of the data in my estimations.

With regard to future research, I would like to estimate potential GDP for China using multivariate production function methods and derive a quarterly output gap series of my own. The monetary policy index (MPI) used in both Chapters 3 & 4 is used to represent the monetary policy stance of the PBOC based on the qualitative and quantitative instruments at its disposal. This qualitative instrument is not directly observable and so is extracted using a Kalman filter in an Unobserved Components Model (See pages 75-78). The set-up of this model assumed that the only variable affecting the monthly growth rate of M2 that can have an AR (1) structure is our unobserved variable, and treats all other factors as shocks. While technically estimating the qualitative instruments in this way seems appropriate, one could argue if it is entirely appropriate to call this series “qualitative instruments”, as it can be anything which has the same time series representation (AR process). So, there is the possibility that the estimated series contains other variables that have not been accounted for in the measurement equation.
Given this possible limitation, future research would involve estimating separate policy indexes through studying PBOC publications or other statistical techniques such as ordered-probit models. I have also been working with Professor Xingsheng Lu at Tongji University in Shanghai regarding the creation of a monetary policy index based on high frequency responses of China’s stock market to monetary policy announcements from the PBOC.

The three equation New Keynesian (NK) model is most often estimated as a system of equations, as opposed to an equation by equation approach as used in this thesis. This is done as at least three variables in this model are typically endogenously determined which could arguably lead to inconsistency in OLS estimates. This thesis estimates the three equations over three different time periods however, and so this should not be a problem. As the aim of this thesis was to examine macroeconomic dynamics since the reforms of 1978, it was decided to choose the earliest time period based on available data for each individual equation. This corresponded to 1987 for the Phillips curve, 1991 for the IS curve and 1994 for the monetary policy rule. Also since there is no real consensus about the suitability of these models for the Chinese economy, it seemed more appropriate to establish the suitability of the individual equations before estimating them simultaneously.

Future research will sacrifice the earlier years of reform and calibrate a Markov switching version of a Dynamic Stochastic General Equilibrium Model (DSGE) model for the Chinese economy. DSGE models have become hugely popular for macroeconomic analysis and policy-making in central banks in advanced countries. This model will simultaneously capture the dynamic response of aggregate variables to different shocks to the Chinese economy. Once again, the “China specific” characteristics will need to be taken into account and will add a new dimension and contribution to the area of research. This is, crucially, the next step in the research as estimating these advanced macroeconomic models using the findings of this thesis will provide an excellent insight into how these key variables interact dynamically in the short run.
APPENDIX A – MODELLING CHINA’S REFORM PERIOD

The standard linear regression models which are used in the three equation (PC-IS-MP) New Keynesian (NK) model assume that the parameters of the three equations do not vary across observations. Despite this assumption, structural change (a long-term shift in the fundamental structure of an economy) and structural breaks (the changing of parameters at dates in the sample periods), have played a hugely important role in the development of the Chinese macro economy. Therefore, this thesis will estimate the three equation model for China using the standard linear estimations as a benchmark, before estimating a structural change with multiple break points as well as a non-linear Markov switching model.

(a) Multiple Breakpoint Model (Bai-Perron 1998, 2003)\textsuperscript{102}

The multiple breakpoint model was devised by Bai-Perron (1998, 2003). An important feature of this test is that it allows a researcher to test for multiple breaks at unknown dates. The Bai–Perron (BP) procedure is useful in a series where there has been a large amount of structural change in the time series as it allows the user to find the number of breaks implied by the data, as well as estimating the timing of the breaks and the parameters of the processes between breaks. The methodology can be used to estimate multiple structural changes in a linear model estimated by least squares. It treats the number of breakpoints and their locations as unknown. It therefore improves on work dating back to Chow (1960), who tested for regime change at \emph{a priori} known dates using an $F$-statistic. The pre specification of breakpoints in this manner is arbitrary and often suffers from model specification. Thus the multiple breakpoint model improves the functionality.

Earlier models of multiple unknown breakpoints included the popular cumulative sum control chart (CUSUM) test of Brown \emph{et al.} (1975), which is based on recursive residuals. While extensions of this test were developed by Kramer \emph{et al} (1988) and Chihwa & Ross (1995), there is evidence that the CUSUM test has poor power properties against many practical alternatives (Kramer \emph{et al} 1988; Garbare 1977). Andrews (1993), for example argues that his $\text{SupF}$\textsuperscript{103} test, which is a main component of Bai & Perron’s procedure, is

\textsuperscript{102} Details for this appendix were source from Bai-Perron (1998, 2003), Charfeddine and Guegan (2007), Onder (2009) as well as those mentioned in the main body of text.

\textsuperscript{103} This is a test for parameter stability at each of the different points of a time series. Pioneered by Quandt (1960) and developed by Andrews (1993), it tests for one or more structural break points in the sample of a specific regression equation.

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more powerful than the CUSUM and other fluctuation tests. Indeed, the \( \text{SupF} \) test has the added advantage of an ability to be applied in nonlinear models estimated by Maximum Likelihood (ML) or Generalised Method of Movements (GMM) methods. The general consensus is therefore that the CUSUSM test is not very useful for detecting structural breaks and that the \( \text{SupF} \) test provides a superior alternative (Berry 1995).

If we consider the below linear regression with \( m \) breaks.

\[
y_t = a_1 + b_1 \psi_t + e_t,
\]

\[
: \quad y_t = a_m + b_m \psi_t + e_t
\]

\[
t = T_{m+1}, \ldots, T
\]

Where the breakpoints \((T_1, \ldots, T_{m+1})\) are treated as unknown. The Bai-Perron estimation is based upon least square estimates of, in this case, \(a_i, b_i\), and are obtained by minimizing the sum of squared of residuals.

\[
\sum_{i=1}^{m+1} \sum_{t=T_{i-1}+1}^{T_i} (y_t - a_i - b_i \psi_t)^2
\]

To determine the number of breaks, Bai & Perron (1998, 2003) propose three tests or statistics, which they refer to as a “sequential procedure”. Firstly, the \( \text{SupF}_1(k) \) test of the null hypothesis. This tests no structural breaks versus the alternative of a fixed number of breaks\((k)\). Secondly, the application of double maximum test of the null hypothesis. This tests no structural breaks versus the alternative of an unknown number of breaks given some upper bound\(M\) \((1 \leq m \leq M)\). In other words a \( UD_{\text{max}} \) and \( WD_{\text{max}} \) statistics are applied\(^{104} \).

And finally, the sequential \( \text{SupF}_l(1 + l | l) \) tests the null hypothesis of \( l \) breaks versus the alternative of \( l + 1 \) breaks.

Before the Bai-Perron is implemented, an initial trimming region needs to be specified to ensure that there is a reasonable number of degrees of freedom to calculate an initial error sum of squares. The trimming specification will also determine the maximum number of breaks and minimum state or regime size. The trimming imposed in the models of

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\(^{104} UD_{\text{max}} \) statistic is the maximum value of the \( \text{SupF}_l(M)F \) statistic where \( M \) represents an upper bound on the possible number of breaks. The \( WD_{\text{max}} \) statistic weights the individual statistics so as to equalise the \( p \)-values across the values of \( m \).
this thesis is 0.15 and allows the procedure to search for a maximum of five breaks. This is the standard specification for the sample sizes used in this thesis’s estimations.

(b) Markov Switching Model (Hamilton 1989, 1994)

While Bai & Perron’s (1998, 2003) multiple breakpoint model is useful in examining changing dynamics over time, it does not allow for switching between different states of the economy. Different policy regimes, institutional reforms and other changes which one would expect from an economy in transition could shift variables like inflation expectations, potential output levels etc. The Markov switching (MS) model, developed by Hamilton (1989), provides a platform in which to model the dynamics of macroeconomic variables in an economy which has been subjected to dramatic and substantial structural change. The advantage of this nonlinear model over the standard linear favourites such as AR, MA and ARMA models is that it is able to represent more dynamic patterns such as asymmetry and non-linearity. This makes it a very useful tool for examining economies that have experienced economic reform and institutional and structural change as one would expect asymmetric policy responses during periods of such great change. This model would therefore seem to provide a good specification in which to model an economy which has undertaken an enormous amount of institutional and sectorial reform such as the Chinese economy. The main idea behind the MS model is that an observed system switches between a finite number of discrete states according to an unobserved process. Under the Markov switching approach, the range of possible outcomes is split into \( m \) states, denoted by \( s_i \), \( i = 1 \ldots m \), correpsonding to \( m \) regimes. In other words, it is assumed that the dependent variable in an estimation, let’s call it \( y_t \), switches states according to some unobserved variable, \( s_t \), that takes on integer values (Brooks 2014). Movements of the state variables between states are governed by a Markov process (thus the name Markov switching model). A Markov process is one where the probability of being in a particular state is only dependent upon what the state was in the previous period. The Markov property can be expressed mathematically as

\[
P[a < y_t \leq b | y_t, y_{t-1}, \ldots, y_{1-1}] = P[a < y_t \leq b | y_{t-1}]\]

This equation states that the probability distribution of the state at any time, \( t \), depends only on the state at time \( t - 1 \) and not on the state present at times \( t - 2, t - 3, \ldots \). Hence the
Markov process is not path dependent. The switching mechanism is controlled by an unobserved state variable \( s_t \). In the context of macro econometric modelling we can think of the discrete hidden states as different monetary or exchange rate policy regimes or different levels of economic activity (Hamilton 1989, Hamilton 1994, Krolzig 1997).

The model involves multiple structures that can characterise the time series behaviour in different states. By permitting switching between these structures, the model is able to capture more complex dynamic patterns. The MS model differs from the Bai-Perron (1998, 2003) method as it allows for frequent changes of random time points. It is therefore arguable that the MS framework is more suitable for describing correlated data that exhibit distinct dynamic patterns during different time periods (Kuan 2002). An interesting feature of the MS model is that the filtered probabilities can be interpreted as the agent’s belief that the economy is in one of the possible states that describe the economy.

If we take the below simple MS model specification;

\[ y_t = a_{st} + b_{st} \psi_t + e_t \]

Where \( e_t \sim i.i.d. N(0, \sigma^2_{e,t}) \) and with unobserved state \( s_t \), which is assumed to follow a Markov chain of order 1 with transition probabilities \( p_{ij} \). The transition probability \( p_{ij} \) gives the probability that state \( i \) will be followed by state \( j \).

\[ P_{ij} = \Pr[ s_t = j \mid s_{t-1} = i ] \]

\[ \sum_{i=1}^{M} p_{ij} = 1, \quad \forall i, j = 1, \ldots, M \]

It is often convenient to collect the transition probabilities in an \((M \times M)\) matrix \( P \) known as the transition matrix:

\[
P = \begin{bmatrix}
p_{11} & p_{21} & \cdots & p_{M1} \\
p_{12} & p_{22} & \cdots & p_{M2} \\
\vdots & \vdots & \ddots & \vdots \\
p_{MM} & p_{2M} & \cdots & p_{MM}
\end{bmatrix}
\]

The row \( i \), column \( j \) element of \( P \) is the transition probability \( p_{ij} \). To demonstrate, in the above matrix, the row 2 column 1 element gives the probability that State 1 will be followed by State 2. Let us for example, say that at time \( t \), the state of the economy \( s_t \) is classified as either high inflation in \( s_t = 1 \) or low inflation in \( s_t = 2 \). In our estimation let us assume that the model gives us a probability of 95% of being \( p_{11} \) and 5% of being \( p_{21} \). What these

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105 Details on the Markov process were obtained from Brooks (2014), Chapter 10 and Hamilton (1994)
values tell us is that if the economy is in a state of low inflation in the previous period, it
tends to stay in a low inflation state with a very high probability of 95%. On the other had
the probability of being in a low inflation state in the previous period and switching to a high
inflation state is low at just 5%.

The estimation of the Markov switching model depends on maximum likelihood. The
maximization of likelihood function of the model requires an iterative estimation technique to
obtain estimates of the parameters of the model and the transition probabilities\textsuperscript{106}. With the
parameters identified, it is then possible to estimate the probability that the variable of
interest follows a particular regime. It is also possible to derive the smoothed state
probabilities which indicate the probability of being in a particular regime or state. An
important question concerns the number of states or regimes to be included in the model. As
there are often relatively few transitions among states, it is difficult to estimate strictly
exogenous explanatory variables accurately. For this reason, most applications assume only
two or three states (Hamilton 2005). Another key point is that the Markov switching model
is relatively easy to implement because it does assume any \textit{a priori} knowledge of an arbitrary
time period or event. Instead, the regime classification in this model is probabilistic and
determined by the data (Kuan 2002).

\textit{Summary}

The use of these two econometric techniques allows for the parameter constancy and the
symmetry assumptions of the standard Phillips curve, IS curve and Taylor rule to be tested.
Typically, these three models assume parameter constancy, which makes them subject to the
Lucas critique (1976) i.e. imposing the view that economic agents respond in the same
manner to shocks over time, irrespective of changes in policy regime. Obviously, omitted
parameter inconstancies can generate serious consequences for policy-making if the
relationships are over or underestimated (Demers 2003). Therefore, the models estimated in
this thesis can examine the effect of the economic reform and structural change that the
Chinese economy has experienced without the restrictions of standard linear models. Also,
by estimating two separate models, the multiple breakpoints and the MS model, over the
same time period, it adds a certain degree of credence and robustness to any results.

\textsuperscript{106} For more details on these technique and the maximum likelihood see Hamilton (1994) and Kim & Nelson
(1999)
APPENDIX B – CHINA’S EXCESS CAPACITY & THE CHINESE OUTPUT GAP

1. China’s Excess Capacity

Many recent studies have tried to examine the level of output in China relative to its potential (see for example IMF 2012, 2014b, Zhang et al 2013 and Porter 2010). This is not a straightforward undertaking however. The pattern of economic growth in China over the last thirty years has been characterized by very high rates of savings and investment, massive transfer of unskilled labour from the agricultural to urban non-agricultural sectors (see page 26) cheap labour cost, low level of labour education, low level of technical innovation, and heavy dependency on external demand (Wang et al 2008). The high rate of investment (which began with the investment boom in the early 1990’s, see page 11) combined with surplus labour in particular has led to a number of macroeconomic imbalances (IMF 2012). Most notably, this investment boom created capacity for which there was no corresponding demand. Throughout the 1990’s, China’s industrial census\textsuperscript{107} for example revealed large pockets of idle capacity across many branches of industry. The Chinese press chronicled widespread over supply of both agricultural and industrial products during this period (Rawski 2002). The National Bureau of Statistics (NBS) also reported that between 1992 and 2002, the average capital utilization rate in China was 69%, well below the international norm of between 79\%-82\%\textsuperscript{108}. The strong GDP growth that China has experienced over the last twenty years has served only to increase investment, particularly in sectors such as manufacturing, often crowding out consumption. This has resulted in a further deterioration in the relationship between the demand and supply side of the economy.

Several other factors contribute to the problem of excess capacity in China. A prime example is China’s institutional and political environment, which often result in central and regional governments propping up largely inefficient SOE’s (see page 94). China’s historically high savings rate is another contributing factor. This often means that, relatively speaking, consumption makes up a small percentage of GDP (see for example Figure 1, page 12) and that excess capacity can only be mopped up by further investment or exports.

\textsuperscript{107} Chinese industrial census data can be accessed at \url{http://www.chinadataonline.org/member/hygk/}
\textsuperscript{108} The international standard for capital utilisation is based on historical data obtained in Brazil, the Euro Area, Japan and the United States among others (Asian Development Bank 2015).
2. China’s Output Gap

The IMF (2015) define the output gap as the deviation of actual from potential output, as a percent of potential. In the below equation, $y$ denotes actual output (measured by real GDP) and $y^*$ represents potential output, which is defined as the output an economy could produce if all factors of production were operating at their full employment rates of capacity.

The output gap can then be represented as: $\bar{y} = \frac{y - y^*}{y^*} \times 100$

Gerlach and Peng (2006) point out that there two broad approaches\(^{109}\) to estimating potential output and thus the output gap for China.

1. The production function approach, which makes use of information regarding the sources of growth, that is, factor accumulation and the state of total factor productivity.

2. Identifying the trend in real GDP with potential output and to use time series techniques, such as filtering to estimate it.

We therefore will examine these two techniques for our Chinese output gap data.

1. Production Function

A main advantage of the production function approach is that it provides an understanding of the sources of growth. However, to estimate a level of potential output in this way requires the need for high quality data on the capital stock and the labour force. The reasons that this may be an issue for China have been well documented in Chapter 2 of this thesis (for example see pages 22 and 28). Scheibe (2003) devotes an entire paper to the calculation of a Chinese output gap. The author points out the issues in estimating potential output for China ranging from limited number of post reform observations, badly measured data, absence of proxies for capacity utilisation or hours worked, no reliable inventory data not to mention the

\(^{109}\) More recently Zhang and Murasawa (2011, 2012); Zhang \textit{et al} (2013) have estimated a measure of output gap for China based on a multivariate dynamic model featuring distinct interactions among real output, inflation, money, and the exchange rate. These estimations are beyond the scope of this thesis however.
large amount of structural change which has been discussed throughout this thesis. Given these obstacles, this thesis considers a production function output gap calculated by Oxford Economics Global Economic Databank, given the fact that this organisation has access to data not widely available to other databases\textsuperscript{110}. This variable is estimated as follows.

“We construct our measure of potential output bottom up by looking at the inputs into the production function (labour supply, capital accumulation and the components of TFP). Subsequently, we benchmark this against actual GDP to period where we feel the economy was operating at potential to ensure the level of actual and potential GDP at those moment is equal and the output gap is zero” (Alessandro Thesis –China Economist, Oxford Economics 2014).

\textbf{Figure B.1 – Production Function Output Gap}

2. Filtering

A frequently used tool in macroeconomics is the Hodrick-Prescott (HP) filter, which decomposes actual output into a long-run trend and cyclical components. This statistical method does not use any information regarding the determinants of each of the components, but provides a useful approximation of potential output growth. While the time series approach is easy to implement, it suffers from the drawback that it provides no economic understanding of the sources of growth. Thus, it is arguably best seen as a complement to the more rigorous production function approach. (Gerlach & Peng 2006). Therefore, we will

\textsuperscript{110} This includes data on wages, labour, primary, secondary and tertiary activity, employment, incomes and consumer spending, and retail sales as well as other series of importance. (See http://www.oxfordeconomics.com/forecasts-and-models/cities/china-cities-and-regional-forecasts/overview )
calculate a HP filter output gap using GDP data from the NBS to compare to Oxford Economics estimations. This will add confidence to our choice of output gap series.

The Chinese National Bureau of Statistics (NBS) publish quarterly GDP data for China. This data is however only available since 1992. Quarterly Chinese real GDP data since 1987 therefore needs to be estimated. This series was calculated using the method developed by Abeysinghe and Rajaguru (2004). This technique involves applying the Chow-Lin related series technique to annual real GDP series which provides us with quarterly real GDP estimates. Developed by Chow & Lin (1971), the basic idea is to find some GDP related quarterly series and come up with a predictive equation by running a regression of annual related series. Then, the quarterly figures of the related series are used to predict the quarterly GDP series and adjust to match the annual aggregates. The Chinese quarterly GDP data can be seen in Figure B.2 (a), the HP filter applied to this series in Figure B.2 (b) and finally the calculated output gap is Figure B.3

**Figure B.2 – Hodrick-Prescott Filter of Chinese GDP Data**

(a) **Chinese quarterly GDP**

(b) **HP Filter**

**Figure B.3 – Production Function Output Gap**
Comparison of both Series

Both the production function output gap and the HP filter output gap are plotted together in Figure B.4. There a noticeable difference in the 1987-1989 period. The HP filter estimation shows a highly positive output gap during this period with the production function gap showing a negative value. The significance difference in the HP filter estimation in this period may be explained by the arguments of Giorno et al. (1995). The authors of this paper suggest the HP filter method often falls victim to an endpoint problem. In part this reflects the fitting of a trend line symmetrically through the data. If the beginning and the end of the data set do not reflect similar points in the cycle, then the trend will be pulled upwards or downwards towards the path of actual output for the first few and the last few observations. For example, for those countries which are slower to emerge from a recent recession, an HP filter will tend to underestimate trend output growth for the current period. Other than this discrepancy, the two series seem to follow a similar pattern with output operating above or below potential in similar periods.

The similarity of these two techniques using two different data sets adds robustness to the use of the Chinese output in our empirical estimations. Given that the production function is often seen as the optimal methodology in estimating an economy’s potential output (Gerlach & Peng 2006), we use the production function estimate of potential output measure as calculated by Oxford Economics\textsuperscript{111}.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{output_gap_comparison.png}
\caption{Output Gap Comparison}
\end{figure}

\textsuperscript{111} Estimations of the models in Chapters 3, 4 & 5 were also carried out using the HP filter output gap method. There was not a huge difference in the results.
APPENDIX C – SUMMARY STATISTICS FOR PHILLIPS CURVE VARIABLES

### SUMMARY STATISTICS FOR PERIOD 1 & 2

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<thead>
<tr>
<th>Statistic</th>
<th>Period 1</th>
<th>Period 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean on inflation</td>
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<td>Standard deviation of inflation</td>
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<tr>
<td>Mean on output gap</td>
<td>-2.71%</td>
<td>0.01%</td>
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<td>Standard deviation of output gap</td>
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<td>1.70%</td>
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<td>Mean on NEER</td>
<td>-6.12%</td>
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</tr>
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### SUMMARY STATISTICS FOR STATE 1 & 2

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<th>State 2</th>
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<td>Standard deviation of inflation</td>
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</tr>
<tr>
<td>Mean on output gap</td>
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<td>0.02%</td>
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<tr>
<td>Standard deviation of output gap</td>
<td>1.78%</td>
<td>1.80%</td>
</tr>
<tr>
<td>Mean on NEER</td>
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<tr>
<td>Standard deviation of NEER</td>
<td>5.22%</td>
<td>14.88%</td>
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APPENDIX D - DERIVING THE IS CURVE

Clarida et al (1999) state that the modern IS curve equation is obtained by the log linearization\(^{112}\) of the consumption Euler equation (sometimes referred to as the Keynes-Ramsey equation) that arises from the households optimal saving decision after imposing \(Y_t = C_t + G_t\). This is the market clearing equilibrium condition that consumption is composed of output – government expenditure. In other words, total output is split between total output and government expenditure.

**Log-Linearizing the Euler Equation**

The Euler equation can be written as,

\[
U'c_t = \beta E_t [U'(c_{t+1})]i_t
\]

Suppose you want to purchase 1 more asset. You must reduce your consumption today by 1. The cost is then current marginal utility.

The gain is the extra return in the next period, \(i_t\).

We need to use this Euler equation to arrive at the IS curve. This is difficult however due to its non-linear nature. To linearize, a first order Taylor series approximation is calculated. This method involves taking the derivative of the expressions and evaluating the derivative at full employment levels. The difference between the variable at time \(t\) is then multiplied by the full employment level.

So, if assume the utility function \(U(c_t)\) is,

\[
U(c_t) = \frac{c_t^{1-\gamma}}{1 - \gamma}
\]

The marginal utility is then

---

\(^{112}\) Sims (2011) defines the process of log-linearization as taking the natural logs of the system of nonlinear difference equations. Then linearizing the logged different equations about a steady state and simplify until a system of linear equations is achieved, where variables of interest are % deviations about a point (steady state).
\[ c_t^{-\gamma} \]

By taking the first-order Taylor series approximation around \( c_f \)

\[ c_t^{-\gamma} \approx c_f^{-\gamma} - \gamma c_f^{-\gamma - 1} (c_t - c_f) \]

Reverting back to the Euler equation

\[ U'c_t = \beta E_t [U'(c_{t+1})]i_t \]

\[ c_t^{-\gamma} = \beta E_t [c_{t+1}^{-\gamma}] i_t \]

If we then let \( i_t \) be full employment interest rate, the Euler equation becomes,

\[ c_f^{-\gamma} = \beta [c_f^{-\gamma}] i_f = \beta i_f = 1 \]

Linearizing the Euler Equation, as before using the first-order Taylor series approximation

\[ c_t^{-\gamma} = \beta E_t [c_{t+1}^{-\gamma}] i_t \]

\[ -\gamma c_t^{-\gamma - 1} (c_t - c_f) = \beta i_f E_t [-\gamma c_t^{-\gamma - 1}(c_t - c_f)] + \beta c_f^{-\gamma} (i_t - i_f) \]

\[ -\gamma c_t^{-\gamma} (c_t - c_f) / c_f = \beta i_f E_t [-\gamma c_t^{-\gamma} (c_t - c_f) / c_f] + \beta c_f^{-\gamma} (i_t - i_f) / i_f \]

Define variables as % deviation from full employment so...

\[ \left( \frac{c_t - c_f}{c_f} \right) \]

can be rewritten as \( \bar{c}_t \) = consumption as % deviation from full employment. Cancel common terms and use result from full employment interest rate;

\[ -\gamma \bar{c}_t = -\gamma E_t (c_{t+1}) + \bar{i}_t \]

To Log Linearize Euler Equation dividing by \( \gamma \) and removing accents for simplicity we can we write as;

\[ c_t = E_t (c_{t+1}) - \alpha i_t \]
Where $\frac{1}{\gamma} = \alpha$ = the coefficient that indicates the sensitivity of current consumption to changes in the real interest rate or the intertemporal elasticity of substitution.

Finally, we use the Fisher (1930) relationship i.e. the real interest rate, $r_t$ = the nominal interest rate, $i_t$ − the expected inflation rate.

$$r_t = i_t - E_t(\pi_{t+1})$$

$$c_t = E_t(c_{t+1}) - \alpha(i_t - E_t(\pi_{t+1}))$$

**Linking the Log-Linearized Euler Equation to the IS Equation**

Since in equilibrium we stated that $Y_t = C_t + G_t$, we can re-write the log linearized consumption Euler equation as follows….

$$(y_t - \bar{Y}_t) - g_t = -\alpha(i_t - E_t(\pi_{t+1})) + E_t(y_{t+1} - \bar{Y}_{t+1}) - g_{t+1}) + \alpha r_t + \varepsilon_t$$

$$(y_t - \bar{Y}_t) = \text{output gap} = \hat{y}_t$$

Rearranging we get the modern IS curve

$$\hat{y}_t = E_t(\hat{y}_{t+1}) - \alpha(i_t - E_t(\pi_{t+1})) + \nu_t$$

Where $\nu_t = E_t(\Delta y_{t+1} - \Delta g_{t+1}) + \frac{1}{\sigma} r_t + \varepsilon_t$

The above equation in bold states that current output depends on expected future output, as well as the interest rate. Because individuals prefer smooth consumption, expectations of higher consumption in the future next period (associated with higher expected output) leads them to want to consume more today which raises current output demand. The negative effect of the real rate of current output in turn reflects the intertemporal substitution of consumption. The interest elasticity in the IS curve, represented as $\alpha$ corresponds to this.

Finally, the disturbance term $\nu_t$ is a function of expected changes in government purchases relative to expected changes in potential output. Since this term $\nu_t$ shifts the IS curve, it is interpreted as a demand shock (Clarida et al 1999).
APPENDIX E113 - THE KALMAN FILTER

A useful method for extracting unobserved variables is to represent the model linking the unobserved variables and the observed variables in a State-Space representation according to Kalman (1960), (1963). This approach starts by setting the model in the State-Space format, and runs a set of recursions after having established appropriate starting conditions. The Kalman filter provides an easy to program, computationally efficient algorithm, and is used in the estimation of unobserved component. The Kalman filter is an iterative process. In other words, starting from one period’s estimates of the state variables, it uses the observable data for the next period to update these estimates.

Below is a brief description of this method.

A State-Space Model consists of two equations:

1. **A Measurement Equation** – This is an equation that describes the relationship between observed and unobserved variables. It maps the observed variables to the unobserved variables we want to estimate.

2. **A Transition Equation** – This equation then describes the dynamics of the unobserved variables.

Taking the measurement equation as the following:

\[ u_t = x_t A_t + e_t \]
\[ e_t \sim iid \ N(0, R) \]

- \( u_t \) is the vector of the observed variables at time \( t \).
- \( A_t \) is the vector of the unobserved variables.
- \( x_t \) is the matrix of coefficients which connects the unobserved variable with the observed variables.
- \( e_t \) is the measurement equation error. It is normally distributed and has covariance matrix \( R \).


---

113 Details for this appendix were sourced from Cuthbertson et al (1993), Kim & Nelson (1999) & Commandeur & Koopman (2007).
The transition equation can be represented as:

\[ A_t = F_t A_{t-1} + v_t \]

\[ v_t \sim iid \ N(0, Q) \]  

(4)

\( F_t \) is a matrix which defines the transition process and dynamics of the unobserved variable.

\( v_t \) is the transition equation error. It is normally distributed and has covariance matrix \( Q \).

When a model is written in the form of these two distinctive equations, it is known as a State-Space form. The Kalman filter can then be applied to these State-Space equations to yield a set of recursive equations. This procedure calculates an optimal estimator of the unobserved variable at time \( t \) given all the information available at time.

The recursive process carries out two steps repeatedly.

1. Prediction – At the beginning of time \( t \), the model calculates an optimal estimator of unobserved variables.
2. Correcting/Updating – At the end of time \( t \), the model corrects or updates the estimator of unobserved variables

The unobserved states/variables are then extracted in the following way.

- At first, initial values of parameters are set. This is commonly done through a simple OLS estimation.
- The Kalman filter then uses the recursive procedure above to generate a series of one step ahead prediction errors.
- At this point, the Kalman filters recursive equations have completed their requires task and standard Maximum Likelihood procedures are used to estimate the unobserved states/variables.

---

114 A recursive equation is one that is used to determine the next term of a sequence using one or more of the previous terms in that sequence.
# APPENDIX F – SUMMARY STATISTICS FOR IS CURVE VARIABLES

## SUMMARY STATISTICS FOR OLS IS CURVE

<table>
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<th>Statistic</th>
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<tr>
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<td>-1.0%</td>
</tr>
<tr>
<td>Standard deviation of output gap</td>
<td>2.1%</td>
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<tr>
<td>Mean of RIR</td>
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</tr>
<tr>
<td>Standard deviation of RIR</td>
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</tr>
<tr>
<td>Mean of MPI</td>
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</tr>
<tr>
<td>Standard deviation of MPI</td>
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</tr>
<tr>
<td>Mean of demand shock (exports)</td>
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</tr>
<tr>
<td>Standard deviation of demand shock (exports)</td>
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</tr>
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</table>

## SUMMARY STATISTICS FOR PERIOD 1 & 2

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<th>Period 2</th>
</tr>
</thead>
<tbody>
<tr>
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<td>-0.8%</td>
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<tr>
<td>Standard deviation of output gap</td>
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<td>1.6%</td>
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<td>Mean of MPI</td>
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<td>Standard deviation of MPI</td>
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<td>1.3%</td>
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<tr>
<td>Mean of demand shock (exports)</td>
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<tr>
<td>Statistic</td>
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<td>State 2</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>----------</td>
<td>----------</td>
</tr>
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<td>Mean of output gap</td>
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<td>1.8%</td>
</tr>
<tr>
<td>Mean of MPI</td>
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<td>Mean of demand shock (exports)</td>
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<td>shock (exports)</td>
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### SUMMARY STATISTICS FOR OLS MONETARY POLICY RULE (MPI)

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<td>Mean of inflation gap</td>
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<td>Standard deviation of inflation gap</td>
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<td>Standard deviation of MPI</td>
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<td>Mean of exchange rate</td>
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### SUMMARY STATISTICS FOR PERIOD 1 & 2

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<td>Standard deviation of output gap</td>
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<td>Mean of inflation gap</td>
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<td>1.3%</td>
</tr>
<tr>
<td>Mean of MPI</td>
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<td>-0.4%</td>
</tr>
<tr>
<td>Standard deviation of MPI</td>
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<td>1.3%</td>
</tr>
<tr>
<td>Mean of exchange rate</td>
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<td>1.6%</td>
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<tr>
<td>Standard deviation of exchange rate</td>
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<td>4.1%</td>
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### SUMMARY STATISTICS FOR STATE 1 & 2

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<td>-0.9%</td>
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<tr>
<td>Standard deviation of output gap</td>
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<td>1.8%</td>
</tr>
<tr>
<td>Mean of inflation gap</td>
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<td>-0.7%</td>
</tr>
<tr>
<td>Standard deviation of inflation gap</td>
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</tr>
<tr>
<td>Mean of MPI</td>
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</tr>
<tr>
<td>Standard deviation of MPI</td>
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<td>1.1%</td>
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<tr>
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</tr>
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<td>Standard deviation of exchange rate</td>
<td>5.5%</td>
<td>7.4%</td>
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</table>
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