Japanese quantitative easing: The effects and constraints of anti-deflationary monetary expansions

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JAPANESE QUANTITATIVE EASING:
THE EFFECTS AND CONSTRAINTS OF ANTI-DEFLATIONARY MONETARY EXPANSIONS

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Declaration of Authenticity

I, the undersigned, hereby declare that this dissertation has been compiled by myself using available information in published books and journals, documentation, articles, and internet sources duly referred to in my bibliography.

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Abstract

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Summary

The aim of this dissertation is to empirically analyse the effects of the Bank of Japan's anti-deflationary Quantitative Easing Policy carried out between March 2001 and April 2006. In doing so, this study also reviews the zero bound to interest rates, defined as the primary constraint to the effectiveness of conventional monetary policy at the interest rate floor. The results of the economic models contained in this study confirm the economic significance of a sustained increase in liquidity in fostering a return to inflationary pressures. Moreover, the findings of the study confirm that effective anti-deflationary policies may not necessarily entail extreme measures on the part of a central bank; on the other hand, credibility coupled with a resolved commitment may very well be enough to provide for positive macroeconomic repercussions.

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LIST OF ACRONYMS

AC – Autocorrelation

ADF – Augmented Dickey-Fuller

ARIMA – Autoregressive Integrated Moving Average

ARMA – Autoregressive Moving Average

BIS – Bank for International Settlements

BOJ – Bank of Japan

CABs – Current Account Balances of Financial Institutions held at the Bank of Japan

CRDW – Cointegrating Regression Durbin-Watson

DF – Dickey-Fuller

DSP – Difference-Stationary Process

EG – Engle-Granger

FRBSF – Federal Reserve Bank of San Francisco

GDP – Gross Domestic Product

IMF – International Monetary Fund

JGBs – Japanese Government Bonds with maturities of more than 1 year

M2+CDs – M2 + Certificates of Deposit

PAC – Partial Autocorrelation

QEP – Quantitative Easing Policy

TB – Japanese Six-Month Treasury Bills

TSE – Tokyo Stock Exchange

TSP – Trend-Stationary Process

ZIRP – Zero Interest Rate Policy

Regression Variables used in this study:

M2CDS = M2 + Certificates of Deposit

CABS = Current Account Balances of Financial Institutions Held at the Bank of Japan

RATES = Japanese Interest Rates on Newly-Issued Ten-Year Government Bonds

YIELDS = Yields on Ten-Year JGB future contracts listed on the TSE

AR (*t*) = Autoregressive term with lag (*t*)

MA (*t*) = Moving Average term with lag (*t*)

SAR (*t*) = Seasonal Autoregressive term with lag (*t*)

Chapter One

INTRODUCTION

Monetary authorities have throughout the years played host to a seemingly continuous struggle against undue movements in prices, with most of their efforts focussed on limiting inflation. Considerably less attention, however, has been paid to deflation, a situation of persistent downward pressures on prices. The reason for this discrepancy in emphasis is primarily due to the very limited number of deflationary episodes throughout modern economic history, which is in stark contrast to the unrelenting inflationary climate that has so far been a hallmark of most of the world's economies.

The past few years have witnessed, nonetheless, a notable increase in studies dealing with deflation, particularly as more and more central banks adopt strict inflation targets (IMF, 2003) (Appendix 1: Figure 1). The primary catalyst of this promulgation in deflation analysis has undoubtedly been Japan's deflationary experience. For more than ten years between 1995 and 2006 Japan's ailing economy provided economic circles with an actual case-study of deflationary pressures at work (Ahearne, 2002). Japan's prolonged deflationary spiral was buttressed by expectations of future lower prices, making it extremely hard for the economy to move back towards more normalised expectations of higher future prices (Svensson, 2005). Moreover, the overwhelming difficulties faced by Japanese central bankers in ridding Japan of deflation showed clearly that the conventional instruments of monetary policy used traditionally in the fight against inflation were no longer applicable under a deflationary scenario characterised by deeply-rooted deflationary expectations (IMF, 2003).

Seen in this light, economic theory in the aftermath of the Japanese experience no longer assumes deflation simply as inflation with a negative sign but rather as a wholly distinct economic phenomenon requiring its own blend of preventive and remedial measures, particularly when deflation becomes entrenched in an economy due to deflationary expectations (Buiter, 2003). Economic theory proposes a number of measures that may be introduced in such scenarios, among the more salient being the outright purchases of long-term bonds and other financial instruments, lowering the yield curve on long-term bonds and widening the range of assets eligible for collateral for bank borrowing from the central bank (IMF, 2003).

These policy proposals carried out in unison were the mainstay of a series of systematic monetary expansions carried out between 2001 and 2006 by the Bank of Japan (BOJ) in an aggressive quantitative easing policy aimed at flushing the Japanese banking sector with excess liquidity. Quantitative easing remains to this day a controversial topic in monetary economics, with divergent opinions on its success and effectiveness (Kirchner, 2006). Its significance remains nothing short of unique however given that it is one of very few policies which offer insights into the conduct of monetary policy at a binding zero interest rate floor. It is also a veritable showcase into the vital importance of fostering inflationary expectations as a key weapon in fighting deflation.

This study attempts to analyse the effects of quantitative easing on three key Japanese economic indicators, namely: Japanese M2+Certificates of Deposit; Japanese long-term interest rates on newly-issues ten-year government bonds; and the yields on ten-year Japanese government bond future contracts listed on the Tokyo Stock Exchange. Quantitative easing is measured as the first difference in the accounts of commercial banks held at the Bank of Japan, and captures in a direct manner the rapid expansion of Japan's monetary base (Maeda et al, 2005). Japanese M2+Certificates Deposit is a key indicator of Japanese economic performance (Kirchner, 2006), whereas the long-term government bond interest rate is used as a proxy for long-term monetary policy. The yield on ten-year government bond future contracts is used as a proxy for general expectations regarding the performance and return of Japanese long-term government bonds.

In analysing the effects of Japanese quantitative easing, Chapter Two looks at the literature behind quantitative easing and the zero bound to interest rates with particular reference to the literature pertaining to the Japanese experience. Chapter Three reviews the methodology of this study through an explanation of the data and economic models used. Chapter Four presents the results and implications of the economic models, the analysis of the limitations of this study and a number of relevant recommendations. Chapter Five concludes by putting forward the author's considerations on the relevance of such studies in the light of an increased tendency on the part of many of the world's major central banks in favour of low-inflation targets.

Chapter Two

LITERATURE REVIEW

This chapter presents firstly the principal economic literature with respect to deflation and the zero bound to interest rates, defined as that interest-rate floor below which conventional monetary policy loses much of its effectiveness. This is followed by a review of the literature pertaining to monetary policy alternatives available at this zero bound. Consideration is then given to a number of theoretical papers on quantitative easing as well as various empirical studies on the effects of quantitative easing on the Japanese economy.

2.1 DEFLATION

> *'In its most vicious form, deflation is undeniably a calamity. Although central banks around the world have spent the past two decades worrying about inflation, a fall in the general level of prices can have far worse consequences.'* (The Economist, 1998)

Deflationary episodes throughout history have been few and far between, and as a result, there remains to this day an apparent perplexity surrounding the popular perception of deflation. William Buiter (2003) defines deflation as *"a sustained decline in the general price level of current goods and services, that is, a persistently negative* *rate of inflation"*. Emphasis must be made on a number of points contained within this definition. Firstly, falling prices only constitute deflation when they are *sustained* for a significant period of time. Secondly, deflation must refer to a sustained fall in the price level for *current* goods and services, and not just asset prices or other individual commodity categories. For instance, a persistent fall in house prices on its own is *not* defined as deflation unless it influences other commodity prices and brings about a sustained fall in the relevant overall price indices.

Further consideration is needed in order to move beyond this somewhat constrained definition of deflation. Buiter himself (2003) states four reasons why deflation is not just a negative inflation rate. Firstly, significant deflation may lead to a zero bound to interest rates, which may in turn severely restrict the conduct of conventional monetary policy.[1] This point is confirmed by Yates (2002) and referred to in greater detail in Section 2.3 below. Secondly, the costs to society from deflationary-induced redistributions from debtors to creditors are significantly higher than inflationary-induced redistributions from creditors to debtors. Deflation is, therefore, seen as being more conducive to default and bankruptcy than inflation, particularly since banks are more likely to cut credit lines under deflation than under inflation (IMF 2003). Thirdly, there is the consideration relating to the so-called sacrifice ratio. Comparatively more employment and output are foregone during deflation since it is significantly harder to

[1] The same cannot be said about interest rates under inflationary scenarios, for there exists no theoretical upper bound to interest rates. Lack of central bank credibility may indeed undermine the effectiveness of monetary policy under significant inflationary pressures. In a deflationary scenario, however, monetary policy becomes immediately ineffective at the zero bound, regardless of central bank credibility issues.

induce demand during a deflationary scenario than it is to dampen it during inflation. Fourthly, Buiter states a commonly-held, though still highly valid consideration, that there is indeed a dearth of practical knowledge about deflation due to the scarcity of deflationary episodes throughout history. Comparing different deflationary episodes throughout time and space is an extremely risky task given the economic, monetary and institutional variations that arise in different countries and time periods. This view is echoed by Bernanke (1999), who states that the Japanese scenario is in no way comparable to other seemingly similar deflationary experiences such as those which characterised the United States in the aftermath of the Great Depression.

Understanding what causes deflation in the first place is nevertheless possible through an application of one of the most basic tenets of economic analysis: movements in prices. Deflation implies either a rise in aggregate supply or a fall in aggregate demand, though these two phenomena are very likely to occur in tandem during a deflationary scenario. Supply-driven deflation or technological deflation occurs when a country's producers lower prices in response to consistent improvements in an economy's productive capacity. This was clearly illustrated during the nineteenth century, when copious increases in economic productivity resulted in decades of falling prices (IMF, 2003). Given subsequent increases in demand, the effects of technological deflation are not considered too harmful to an economy. Demand-driven deflation on the other hand occurs when producers lower prices in response to negative demand shocks. Deflation of this sort is very rarely anticipated, and may effectively wreak havoc on previously seemingly bullish economic systems (IMF, 2003), as happened in the United States in the aftermath of the Great Depression (Buiter, 2003).

The Japanese scenario is characterised by both supply and demand-driven deflation, though it is undoubtedly the latter deflation type that was the catalyst responsible for wreaking havoc on the Japanese economy. Demand-deflation buttressed by deflationary expectations was undoubtedly the biggest obstacle to the effectiveness of conventional monetary policy, and was for more than a decade the principal policy headache of the BOJ. The following section reviews in brief the principal literature pertaining to the Japanese deflationary scenario.

2.2 THE JAPANESE EXPERIENCE

Though it is not the intention of this study to present an in-depth analysis of the causes of the Japanese deflationary experience, it is relevant to note some important characteristics of the Japanese scenario, as are mentioned in a number of sources, including Taggart Murphy (1996), Bernanke (1999), the Bank for International Settlements (Nakaso, 2001), Ahearne (2002), Kimura et al (2002), Buiter (2003), and the IMF (2003).

The stratospheric rise of the Japanese economy following the end of World War Two is widely regarded by many as the direct result of extensive cooperation between large firms and financial institutions, with the financial sector being heavily regulated by the Ministry of Finance until it was deregulated in the early part of the 1970s (Nakaso, 2001). Japanese industrial growth throughout the second part of the twentieth century was spurred on by rapid land and housing development, and exhibited very low rates of public share offerings and mergers or takeovers by foreign corporations. Japanese firms were nonetheless able to expand consistently through the acquisition of significant bank loan financing, much of which was obtained by bigger firms as part of an intricate – and at times murky – network of business alliances called *keiretsu.* (Taggart Murphy, 1996). *Keiretsu* alliances were the Japanese version of American conglomerates and South Korean *chaebols*, though with much greater interdependence with respect to their financing partners. The primary objective of the *keiretsu* business structures was to provide long-term employment for Japanese workers, an attitude which was reflected in the overall economy as firms endeavoured for firm growth rather than for profit maximisation. Larger firms within the *keiretsu* maintained their competitive edge in foreign markets by pushing for consistently lower costs and better quality throughout their supply chain. Firms loyal to this *modus operandi* were rewarded with seemingly unlimited sources of finance in the form of extensive loans obtained in the *keiretsu's* name. In turn, banks were guaranteed credit security through informal arrangements whereby *keiretsu* leaders would bail out failed subsidiaries rather than resort to formal litigation procedures. Taggart Murphy (1996) states that:

"Whereas American-style business behaviour is checked with respect to the quest for profits and the threat of litigation, in Japan these two are not at all binding; instead, one finds the constant search for cost reduction and the web of network firms each holding shares in one another."

Spurred on by *keiretsu* growth and ambitious government-led infrastructural initiatives, the Japanese economy witnessed enormous increases in economic capacity. Japanese Real GDP exhibited consistent double-digit growth during the 1960s and 1970s, and grew by nearly 3.8% per annum between 1980 and 1990 (Bernanke, 1999) (Appendix 1: Figure 2). The Japanese economic miracle was nonetheless accompanied by a notable lack of consolidation in Japan's financial sector, particularly its banks, which remained strikingly underdeveloped given the level of growth in the rest of the economy (Nakaso, 2001) This lack of transparency and accountability within the Japanese banking system was ultimately one of the main factors that precipitated the Japanese economic recession following the bursting of the Japanese asset price bubble in 1991 (Ahearne, 2002). For a while it seemed as if Japanese economic resilience would prevail, with GDP growth for 1991 at a level of 2.5%. Japanese financial institutions were by now, however, showing serious signs of economic strain due to extensive non-performing loans backed by very little productive external collateral (Kimura et al, 2002). Problems with Japan's financial system came to a head in the mid-nineties with the bankruptcy of Tokyo Kyowa and Anzen in 1994, followed by a string of high profile bankruptcies culminating in the collapse of Hokkaido Takushoko Bank, Yamaichi Securities, and the Long Term Credit Bank of Japan (Nakaso, 2001). By March 2001 more than 110 financial institutions had collapsed, leaving consumer confidence and investment sentiment in tatters. Domestic spending suffered greatly, pushing Japanese growth rates down to their lowest rates in decades. Price inflation also fell drastically, hitting the zero level in 1995 (Appendix 1: Figure 3). This point is seen by many as the starting point of Japan's decade-long deflationary spiral, characterised by a stagnant economy cemented by deflationary expectations (Ahearne, 2002).

Having briefly considered the literature with respect to some salient factors leading up to Japan's deflationary scenario, it is now pertinent to consider some important studies on the conduct of conventional monetary policy instruments with special emphasis on the liquidity trap caused by the zero bound to interest rates.

2.3 MONETARY POLICY AND THE ZERO BOUND TO INTEREST RATES

Buiter (2003) identifies three conventional instruments of monetary policy: the nominal spot exchange rate, the stock of base money, and the short risk-free nominal interest rate on non-monetary financial claims. Monetary authorities are in theory limited to the free and effective control of only one of these policies at any single point in time, particularly in countries characterised by a high degree of capital mobility and a reasonably small say in global capital markets. The three instruments of monetary policy are considered briefly below.

The use of foreign exchange management – particularly devaluation – as a monetary policy instrument is regarded chiefly as a weapon of last resort. In times of economic stagnation and deflationary pressures however a devaluation of a country's currency may improve that country's trade surplus given that the Marshall-Lerner condition is satisfied (Svensson, 2001). This point is referred to in Section 2.4 in the discussion on monetary policy instruments available at the zero bound to interest rates. The stock of base money as a primary monetary policy instrument on the other hand constitutes a principal pillar of quantitative easing and is therefore considered in Section 2.5.

By far the most widely-used tool of conventional monetary policy however is the short-term interest rate, wielded by central bankers worldwide as a primary tool in their struggle to keep price movements under control. Changes in short-term interest rates induce movements in other key interest rates, influencing the behaviour of economic agents such as banks, firms, and individuals (Suda, 2003). Monetary authorities may also bring about desired changes in consumption and investment demand by credibly announcing future interest rate changes (Bernanke et al, 2004). A reduction in the current short term nominal interest rate will boost both private consumption and investment demand, with the opposite being true for an interest rate rise (Buiter, 2003). In times of inflationary pressures central banks will tend towards increasing the short-term interest rate in a bid to dampen aggregate demand. Similarly, central banks will face increased pressures to lower the current short-term interest rate during periods of deflationary pressure and economic stagnation in a bid to stimulate aggregate demand.

There is a crucial limit however to the extent to which a central bank can lower interest rates. This is called the zero bound level, and is given by that level of interest rates below which further reductions in interest rates are not possible (IMF, 2003). The zero bound to interest rates is illustrated by Yates (2002) using the following example. In a world characterised by only money and default-free government securities, governments would not be able to offer negative interest rates on government securities since individuals would avoid paying the negative interest rates on government bonds by swapping money for bonds. This zero bound to interest rates may not necessarily fall precisely at the zero rate: it will be higher than zero when there are significant advantages to holding money as opposed to holding government bonds. On the other hand, it will be lower than zero when there are significantly higher advantages of holding government bonds to holding money. A valid argument in favour of eliminating the zero bound to interest rates was put forward by Gesell (1949), who proposed taxing money. This proposal however is viewed by economists as somewhat unconventional (Buiter, 2003 and Yates, 2002), and is considered in Section 2.4 below.

An economy caught at the zero bound level to interest rates is therefore unable to stimulate aggregate demand through reductions in the official short-term interest rate, and is said to be caught in a *liquidity trap.* The Japanese scenario between 1995 and 2006 bears striking similarity to this liquidity trap scenario, as shown by analysis of official figures and statements. Throughout the early 1990s the BOJ lowered interest rates in response to lower inflation figures in spite of economic growth of more than 3% per annum during 1995 and 1996 (Kimura, 2002). By 1995 the BOJ had lowered its uncollateralized overnight call rate - Japan's key short-term interest rate - to 0.5% (Kimura, 2002). The BOJ would further reduce this rate to 0.02% in February 1999, following which it introduced its zero interest rate policy in April 1999. In August 2000 the BOJ announced an end to deflation, increasing the official interest rate but lowering it back to zero soon after in what many believed to be an enormous blunder by the BOJ (The Economist, 2006). Throughout 2000, and early 2001, the zero interest rate policy generated little results in terms of stimulating aggregate demand due to the fact that in spite of its remarkably low level, the expansionary effect of the zero interest rate was being dissipated by a falling price level (The Economist, 2006).

A number of notable commentators called for the BOJ to do more with respect to dealing with Japan's deflationary crisis. Krugman (1999) called for the BOJ to make a credible announcement of future inflation. His proposal however was criticised by a number of commentators including Buiter, who stated that adopting a formal inflation target without specifying explicit policy proposals aimed at reaching that target would be like *"spitting in the wind"* (Buiter, 2003). The IMF (2003) reiterated the importance of effective policy as the only tangible instrument capable of breaking deflationary expectations. Bernanke (1999) commented on the BOJ's monetary policy stance, stating that:

> *"Having pushed monetary ease to its seeming limit, what more could the BOJ do? Isn't Japan stuck in what Keynes called a "liquidity trap"? I will argue here that, to the contrary, there is much that the Bank of Japan could do to help promote economic recovery in Japan, [...] a more expansionary monetary policy is needed."*

Having exhausted the conventional interest-rate policy route, and facing repeated calls for renewed strategies in the fight against Japan's protracted deflationary pressures, the BOJ announced the introduction of a new quantitative easing policy in March 2001, in a bid to stave off Japan's deflationary spiral. At that time quantitative easing was, for all intents and purposes, an unprecedented policy strategy; one of a handful of proposed – though untested – monetary policies available at the zero bound interest rate floor. The following section considers the literature with respect to these alternative monetary policies.

2.4 MONETARY POLICY AT THE ZERO BOUND

A number of policies have been proposed as alternatives to the conventional interest-rate route to monetary policy obstructed by a binding floor to interest rates. Among the most important of these one finds more active fiscal stabilisation, taxes on money to lower the zero bound to interest rates, buying assets denominated in foreign currency in the hope of devaluing the exchange rate, money 'rains' or transfers to the private sector, and using open market operations to buy up long government bonds or private sector assets (Yates, 2002). These various options are now considered briefly in turn.

More active fiscal stabilisation implies an outright expansion in the government's fiscal programme either through an increase in capital or current spending (including education, health and defense) or an outright increase in the degree and amplification of automatic stabilisers such as income and unemployment benefits and (lower) taxation. However, an increase in fiscal stabilisation may suffer from time lags, particularly if parliamentary approval is required for its implementation. This is in stark contrast to the relative speed at which monetary policy is introduced and implemented by independent central banks. Increases in fiscal stabilisation may also be thwarted by a general public that indefinitely defers from spending such expansionary fiscal stimuli out of fear of a reversal of such measures once deflation is over, leading to a possible case of Ricardian Equivalence (Yates, 2002).

A tax on money is the next instrument on the list of possible monetary policy alternatives at the zero bound. It was Gesell (1949) who proposed taxing individuals on the basis of their money stocks, arguing that a tax on money would effectively lower the floor on interest rates, allowing governments to offer negative interest rates on other government securities. A tax on money would, in theory, simulate circumstances tantamount to an inflationary scenario. Its primary weakness, however, remains the enormous costs of enforcement. Buiter and Panigirtzolou (1999) propose a system whereby the legal tender of cash becomes conditional on it being periodically presented for re-issue through stamping, punching, or some other easily recognisable sign. Yates (2002) however advises against this policy, citing a clear lack of practical experience in operating such a tax. It is widely assumed that individuals would do their utmost to evade such a tax not simply in order to avoid payment but in a direct effort to preserve the highly-valued anonymity benefits provided by cash-based receipt and payment systems.

A devaluation of currency as proposed by Svensson (2001) - mentioned in Section 2.3 above - is important in the light of this discussion because it introduces an important concept in the study of monetary policy alternatives at the zero bound: central bank printing of money. Bernanke (1999) looks at the Japanese deflationary experience, and argues that the BOJ could have induced a devaluation of the Yen by printing an indefinite amount of money and subsequently buying foreign assets. Foreigners would only sell their assets if the Yen depreciated, and the BOJ could have continued printing money till it did. A subsequent Yen depreciation would have induced inflationary pressures through the associated effects of a long-run appreciation of the currency, a fall in long-term interest rates, and an increase in international demand for domestic assets. This proposal is also referred to by Buiter (2003) who admits that there is reasonable proof that the Marshal Lerner Condition would apply in Japan's long-run scenario – though not in the short-term. Yates (2002) further elaborates on this proposal by arguing, however, that few central banks would in reality be willing to risk debasing their currency for the purpose of carrying out anti-deflationary currency devaluations.[2]

Another monetary policy alternative available at the zero bound consists of so-called 'money rains', or, as they are more commonly known in the literature, Friedman's Helicopter Drop of Money (Yates, 2002). In conventional open market operations monetary authorities and the general public exchange bonds (which yield a positive return under positive interest rates) in return for money (no return). In a liquidity trap, however, both money and bonds yield zero return and hence are seen as being perfect substitutes (Buiter, 2003). A helicopter drop of money would entail in this regard monetary authorities giving out money without requesting bonds or other securities in return. Such a measure would, at least in theory, induce inflationary pressures through an increase in aggregate demand and a lowering of actual real rates. The concept of money rains hinges primarily on money creation, and there is agreement, at least in the literature, that such a proposal would in fact have the desired effects. Buiter calls this policy *"The one that always works"* (Buiter, 2003).

Having said that, there is an element of debate, however, as to how such money rains could be carried out. Yates (2002) calls for cash handouts administered through

[2] This is in addition to the political implications of such a strategy given the sensitive geo-politics of the Dollar-Yen-Yuan relationship.

people's bank accounts and through welfare systems for those not in possession of such bank accounts. Goodfriend (2000) on the other hand calls for monetised tax cuts. Regardless of which method chosen however, there are a number of considerations to be made. Firstly, a money rain might present credibility issues for a central bank engaging in such handouts, particularly if these are carried out repeatedly over a period of time. An economy might over time come to depend on such money rains. Secondly, the wealth effect of such a money rain will only occur if people are not perfectly forward looking. If they are, they will expect government to reverse the money rain in future and will therefore not be influenced by the money rain itself. In this regard however Goodfriend (2000) argues that money rains would still have positive liquidity effects in spite of their zero wealth effect. Yates (2002) states that:

> *"An analogy would be if the central bank were to give out cars to the private sector, and promise to take them back in the future. There would be little wealth effect from the car loan. But while the private sector had extra cars, they could, if they wanted, make extra journeys, which they might value."*

The importance of an increase in liquidity in dampening deflationary expectations – whether through money rains, devaluations financed by printing of money by monetary authorities, or other policy instruments - is also noted by the IMF (2003), which states that historical experience with respect to deflationary episodes shows that a *"large and sustained increase in liquidity"* is essential in fostering inflationary expectations.

It is this increase in liquidity which lies at the heart of the next alternative monetary policy proposed with respect to the zero bound limit to interest rates: quantitative easing. The next section reviews the literature with respect to the conceptual framework at the root of the Bank of Japan's Quantitative Easing Policy carried out between March 2001 and April 2006.

2.5 QUANTITATIVE EASING

On the 19th of March 2001 the Bank of Japan announced a new Quantitative Easing Policy (QEP) intended to eliminate once and for all Japan's deflationary spiral. Advocates of a more expansionary monetary policy applauded the Bank's seemingly invigorated anti-deflationary stance whilst critics of such apparently unconventional policy instruments were somewhat less keen and warned of a heavy price to be paid by the Japanese economy if the BOJ failed yet again to pull the country out of its ten-year deflationary conundrum (Spiegel, 2006). There was a measure of consensus however: firstly, that it was high time that the BOJ intervened more vigorously with respect to the country's ailing zero interest rate policy; and secondly, that the new quantitative easing policy was an unprecedented step into the unknown for any monetary authority (Spiegel, 2006 and Maeda et al, 2005).

A look at the literature will expound on the theoretical concepts of quantitative easing. Quantitative easing is defined by Buiter (2003) as those central bank policies directed towards achieving an increase in the economy's monetary base (Appendix 1: Figure 4) and carried out in tandem with the official interest rate or instead of it when the interest rate is at its lower bound.

The theoretical rationale behind quantitative easing is given by Goodfriend (2000), who argues that such a strategy can in theory provide for increases in broad liquidity services to an economy suffering negative demand shocks, particularly in times of significant deflationary pressures. Goodfriend explains that central bank trades of money for certain long term government bonds can actually increase broad liquidity in an economy, whereas trades of money for short-term governments bonds – typically traded in open market operations - do little to affect broad liquidity, particularly at the zero bound to interest rates (when money and short-term government bonds are seen as being perfect substitutes). The increase in broad liquidity brought on by central bank purchases of long-term government bonds from the public is seen as having two distinct inflationary-generating effects: firstly, it induces economic agents to bid up asset prices as they attempt to rid themselves of this extra liquidity; and secondly it consolidates short-term interest rates at their zero bound and leads to further downward pressures on long-term interest rates.

An important caveat in this respect is the possibility of increased risk inherent in central bank dealings of less liquid long-term bonds, which might expose monetary authorities to increased vulnerability due to default risk. Yates (2002) argues, however, that this increased vulnerability is easily overcome through a credible central bank announcement that it would be in future accepting less liquid bonds, effectively increasingly their liquidity potential.

Moreover, Goodfriend (2000) argues that central banks can further increase broad liquidity in an economy by engaging in trades of money for other illiquid private assets, as well as foreign currency that is viewed as being less liquid than the domestic currency being offered. Monetary authorities may also bring about increases in a country's monetary base through outright financing of government expenditures, transfer payments, and tax cuts (Buiter 2003).

Having seen the primary rationale behind quantitative easing, it is pertinent to note some practical underpinnings of the QEP strategy carried out by the BOJ. Japanese QEP policies consisted almost exclusively of open market operations directed towards long-term government securities, with foreign exchange transactions and outright financing operations not considered an integral part of Japan's QEP strategy (Maeda et al, 2005).

Oda and Ueda (2005) identify two principal policy instruments at the heart of the BOJ's QEP strategy: firstly, a zero interest rate policy (ZIRP), that is, a commitment by the BOJ to keep its official short-term interest rate at zero for as long as the country experienced deflation; and secondly, a significant expansion in the economy's monetary base, providing bank reserves in excess of the amount needed to keep the short-term interest rate at zero (Appendix 1: Figure 5).

The QEP strategy framework consisted of the following three pillars, as specified by Oda and Ueda (2005), Kirchner (2006) and Maeda et al (2005):

a) *Target:* Using commercial banks' and financial institutions' Current Account Balances (CABS) held at the Bank of Japan as the main monetary policy operating target (Appendix 1: Figure 6).[3]

b) *Duration:* A commitment by the Bank of Japan to maintain the provision of ample liquidity through the CABS until the year-on-year increase in Japan's core consumer price index becomes positive on a sustained basis.[4]

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[3] A Current Account Balance at the BOJ is a prerequisite for financial institutions to operate in Japan. By April 2005 (exactly a year before the withdrawal of QEP), the number of parties operating within the BOJ's QEP strategy amounted to more than 150 (Maeda et al, 2005).

[4] An important consideration – though not vital for the sake of this discussion – is that Japan's core consumer price index ignores perishables but considers the price of energy. This point is harped upon repeatedly by The Economist (2006) as a source of bias with respect to Japanese deflationary figures, and is believed to have consistently underestimated Japanese deflationary calculations.

c) *Primary Instrument:* Increasing the outright purchases of Japanese long-term government bonds as the primary instrument for liquidity injections.

Kimura et al (2002) and Oda and Ueda (2005) give some important figures with respect to the BOJ's QEP framework. BOJ outright purchases of long-term government bonds increased from four hundred billion Yen per month in March 2001 to six hundred billion Yen per month in August 2001. This would be further increased to one trillion Yen per month in February 2002 (Appendix 1: Figure 7). CABS at the BOJ – on introduction of QEP – stood at roughly four trillion Yen, the then required amount with respect to bank reserves. The target CABS level was set at five trillion Yen in March 2001, and increased to six trillion Yen in September 2001.[5] By December the target was once again raised to ten to fifteen trillion Yen, and reached a maximum of thirty-six trillion Yen in March 2004 (Appendix 1: Figure 5). The CABS level would hover around the thirty trillion Yen figure until the withdrawal of QEP in April 2006, when the BOJ initiated procedures to reduce the level of excess CABS following modest inflationary increases. The BOJ would increase its official interest rate to 0.25% in July 2006, thus formally bringing to a close its zero interest rate policy and raising interest rates for the first time in six years.[6]

[5] The BOJ would customarily increase CABS significantly during the first three months of the calendar year in order to provide for increased liquidity demands due to the approaching fiscal year-end.

[6] The July 2006 interest hike is sometimes regarded as the first Japanese interest rate increase in more than ten years, ignoring the BOJ's interest rate hike blunder in 2001.

2.6 THE EFFECTS OF QUANTITATIVE EASING

Having considered the theoretical and practical underpinnings of the BOJ's quantitative easing strategy it is now pertinent to note a number of prominent studies on the effects of the quantitative easing process. Empirical studies on the impact of QEP are in strikingly short supply, though this is somewhat inevitable given the relatively short timeframe since QEP was withdrawn by the BOJ in April 2006. A number of studies have, nonetheless, attempted to empirically examine the impact of the BOJ's QEP strategy. Their findings are discussed in turn below.

In one of the earliest studies on quantitative easing, Kimura et al (2002) state that by far the most evident effect of QEP was its role in helping preserve financial market stability by providing Japanese banks with ample liquidity. Quantitative easing is seen in this regard as having mitigated the negative impacts of possible further collapses among Japan's financial institutions, though the authors find few additional significant effects of QEP, stating that the impact of QEP – at the time of the paper being published in 2002 - remained *"highly uncertain and very small, if any."* (Kimura et al, 2002). [7]

Suda (2003) gives a brief but thorough review of QEP, arguing that the increase in CABs by the BOJ reduced the risk of liquidity shortages and maintained a measure of stability within Japan's financial markets. Suda also points towards QEP as having been

[7] The IMF would, in 2003, state that *"the cumulative growth in base money has not been aggressive enough to improve expectations, but it may well have played a role in preventing deflationary expectations from worsening."* (IMF, 2003).

responsible for Japanese long-term rates falling to their lowest level in history, though admittedly she provides little empirical analysis to prove that QEP was the effective catalyst of this fall. Suda claims that there is little evidence of quantitative easing having had significant effects on financial lending and other aggregate economic indicators, stating that: *"an increase in monetary base has hardly had any effect on either economic activity or inflation expectations"* (Suda, 2003). [8]

In another – and more recent – empirical study on quantitative easing, Oda and Ueda (2005) focus on the effects of QEP on interest rates with respect to medium and long-term bonds. The authors – who hail from the Bank of Japan and Tokyo University respectively – tentatively conclude that the BOJ's monetary policy from 1999 onwards functioned primarily through the zero interest rate commitment rather than specifically through QEP-induced open market operations. The Bank's zero interest rate policy strategy resulted in a lowering of the expectations component of interest rates, though with little effects on the risk premium component. The authors fail, however, to find significant effects of the BOJ's QEP policy on Japanese interest rates, though they do find limited evidence pointing towards QEP having had a signalling effect with respect to the BOJ's commitment towards maintaining an accommodative monetary policy regime. This seems to confirm that QEP was intended by the BOJ primarily as a signalling device for the BOJ's ZIRP rather than as an outright economic instrument intended to directly revive Japan's economy.

[8] Kimura and Suda's studies must be seen in the light of a QEP programme still very much in its infancy, and cannot, therefore, be used as conclusive evidence against QEP.

It is Kirchner (2006) who provides one of the principal - and more importantly, one of the few non-BOJ commissioned - analysis of quantitative easing. Kirchner maintains that the BOJ's QEP strategy was constrained by a lack of resolve with respect to carrying out more aggressive monetary expansions. Kirchner states that members of the Japanese Monetary Policy Board considered QEP to be little more than a signalling device for inducing inflationary expectations, effectively relegating the impact of QEP to a simple 'policy duration effect'. This latter effect is repeatedly illustrated through the significant emphasis made by the BOJ with respect to its commitment to maintain quantitative easing whilst at the same time pursuing very little aggressive monetary expansions. Kirchner (2006) alleges that the BOJ did not force excess liquidity on financial institutions but rather accommodated their demands for greater liquidity, varying the increases in CABs with the expected demand for CABs by the financial institutions themselves. This is confirmed in a number of comments made by BOJ staff including deputy governor Yamaguchi, who is quoted by Kirchner as having stressed the importance of an *accommodating* rather than an aggressive QEP stance (Hetzel, 2003 and Kirchner, 2006). This puts further weight to Kirchner's hypothesis that the increase in Japan's monetary base was absorbed by financial institutions themselves rather than passed on to the general public in the form of increased bank lending and consumer and investment expenditure. Kirchner concludes by stating that the QEP could have been less conventional and more aggressive, embracing a more monetarist view of the monetary policy transmission process rather than restricting itself simply to influencing general expectations of future prices through the policy duration effect.

The effects of QEP are also referred to in a number of articles compiled by the Federal Reserve Bank of San Francisco (FRBSF). In an article published in 2006, the FRBSF's Vice-President, Mark Spiegel, states that there is still little evidence of increased lending as a result of QEP, though he does refer to lower long-term interest rates as a possible QEP effect. Spiegel also refers to quantitative easing having favoured weaker Japanese financial institutions and thus having ultimately played an indirect role in postponing structural reforms within the Japanese financial sector, though he insists that the overall effect of QEP had been positive. This is corroborated by The Economist (2006), which states that: *"Although their industry is still overcrowded and they lack clear plans for finding fresh sources of profit, many of them have cleaned up their loan books, are increasing lending and are looking stronger than they have done for a decade."*

2.7 CONCLUSION

The Quantitative Easing Policy strategy carried out by the Bank of Japan between 2001 and 2006 represents an unprecedented monetary policy exercise carried out in the face of significant deflationary pressures. It is undoubtedly a fascinating insight into how monetary policy may operate within the realm of a binding floor on interest rates brought on by persistent deflationary expectations.

As Japan tentatively moves out of its protracted ten-year deflationary conundrum, empirical studies of QEP have confirmed its positive contribution to maintaining a measure of financial stability in Japan's troubled financial sector. This effect of quantitative easing is assumed to have operated primarily through the policy duration effect, signalling the BOJ's resolute commitment to its zero interest rate policy. There is also some evidence of QEP having lowered medium and long-term interest rates, though this evidence remains tentative and at times insignificant. Evidence of the effects of QEP on key Japanese economic indicators such as domestic spending and investment remains scarce, and where available, inconclusive.

The next chapter introduces the economic models and data used in this study together with an explanation of their key components and the subsequent econometric tests conducted.

Chapter Three

THE MODEL

This section provides a description of the econometric models used in this study and an analysis of the dataset used. Consideration is also given to the relevant tests conducted to check for stationarity, cointegration, and serial correlation.

3.1 MODEL AND VARIABLES

An attempt is made in this section to build three econometric models in order to illustrate the effects of the Bank of Japan's Quantitative Easing Policy (QEP). The impact of quantitative easing – measured using the changes in Current Account Balances (CABS) of Financial Institutions held at the Bank of Japan – is tested on three distinct variables: Japanese M2+Certificates of Deposit; Japanese interest rates on newly-issued ten-year government bonds; and the yields on ten-year Japanese Government Bond (JGB) Future Contracts traded on the Tokyo Stock Exchange (TSE). These three dependant variables – together with the explanatory CABs variable – are explained in further detail below.

The explanatory variable in this study is given by the primary target of the BOJ's quantitative easing policy: the *Current Account Balances of financial institutions held* *at the Bank of Japan* (referred to in this study as CABS). Throughout the initial stages of the BOJ's QEP strategy CABS of financial institutions at the Japanese central bank experienced rapid increases as the BOJ sought to flood the Japanese banking system with excess liquidity by increasing its outright purchases of Japanese government bonds. Changes in the CABS variable are therefore directly indicative of the extent and magnitude of the BOJ's QEP strategy, and are, in this light, essential to the purposes of this study.

The *M2 + Certificates of Deposits* variable is one of four key Japanese money stock indicators, and is composed of M1 + Quasi-money + Certificates of Deposits. M1 consists of cash currency in circulation and deposit money. Quasi-money is composed of time and savings deposits, fixed and instalment savings, non-residents' yen deposits, and foreign currency deposits held by money owners. To summarise therefore:

M1:	Cash Currency in Circulation + Deposit Money
Quasi-Money:	(Time and Savings Deposits + Fixed and Instalment Savings + Non residents' Yen Deposits + Foreign Currency Deposits held by Money Owners)
M2 + CDS:	M1 + Quasi-money + Certificates of Deposits

The importance of the M2+CDS variable in light of this study is due to its proxy effect with respect to bank lending, particularly the creation of new deposits for domestic consumption and investment. Changes in M2+CDS are used as measure of movements in financial activity and fluctuations in bank lending and saving. This variable is particularly important given the Japanese economy's high reliance on domestic spending, its customary high savings ratios and the traditional importance given to cash-based payments systems.

The next variable under consideration is the *Japanese long-term interest rate on newly-issued ten-year government bonds* (referred to in this study as the RATES variable). This variable is an essential yardstick of any central bank's long-term monetary policy stance and is essential in the light of this study due to the ineffectiveness of short-term interest rates as a result of Japan's protracted liquidity trap characterised by official short-term interest rates at a zero level. Of particular importance to this study is whether QEP succeeded in influencing changes to Japanese long-term interest rates.

The final variable used in this study refers to *the yields on ten-year JGB future contracts listed on the Tokyo Stock Exchange* (referred to in this study as the YIELDS variable) which are used as a proxy for general expectations regarding the performance and return of long-term government bonds. In a liquidity trap scenario characterised by short-term interest rates at their zero level, the yields on longer-term government bonds become important yardsticks of expectations regarding inflation and future policy decisions. The extent of this signalling effect inevitably depends on the demand and supply conditions of the bonds in question, though the high trading volume inherent in

TSE trading for ten-year JGBs is a relatively good guarantee of an efficient market price which properly reflects demand and supply conditions as well as future price and interest rate considerations.

The three models used in this study are therefore constructed in the following manner: [9]

ΔLog (M2CDs) =	$\beta_1 + \beta_2 \Delta$ Log (CABS) + u_t	(Equation 3.1.1)
Δ (RATES) =	$\alpha_1 + \alpha_2 \Delta$ Log (CABS) + u_t	(Equation 3.1.2)
Δ (YIELDS) =	$\eta_1 + \eta_2 \Delta$ Log (CABS) + u_t	(Equation 3.1.3)

Where:

M2CDS:	M2 + Certificates of Deposit
CABS:	Current Account Balances of Financial Institutions held at the BOJ
RATES:	Japanese Interest Rates on Newly-Issued Ten-Year Government Bonds
YIELDS:	Yields on Ten-Year JGB future contracts listed on the TSE.

Logs are used with respect to Equation 3.1.1 above in keeping with established empirical studies of a similar nature, particularly since it is expected that the relationship between the explanatory and dependant variables is of a curvy-linear

[9] Both models were subsequently modified and fitted with ARMA specifications. The final models are shown in Sections 3.6, 3.7, and 3.8, together with a discussion of the relevant tests carried out.

nature. Equations 3.1.2 and 3.1.3 are expressed in linear-log form in order to facilitate analysis of the impact of CABs on the interest and yield rates variables.

A priori expectations of coefficient signs are assumed to be as follows, though it is important to keep in mind that such expectations are, at best, assumptions, given the uncertain results exhibited by similar empirical studies as illustrated in Section 2.6 above. Nevertheless, the following signs are expected *a priori*:

β_2 = (+) A positive relationship between CABS and M2+CDS. An increase in a country's monetary base as part of an expansionary monetary policy programme is assumed to have a positive effect on M2+CDS, *ceteris paribus.*

α_2 = (-) A negative relationship between RATES and CABS. It is believed that an increase in the outright purchases of Japanese long-term government bonds would have increased their price and brought about a fall in their interest rate. However, it is doubtful whether this fall in long-term interest rates would have persisted towards the end of quantitative easing, which was itself characterised by expectations of increased interest rates and the prospect of future sale of government-held JGBs acquired during the initial stages of the QEP framework.

η_2 = (-) Initial *a priori* rationale with respect to the relationship between YIELDS and CABS would assume a negative relationship between CABS and the yields on long-term JGB contracts, based on the belief that an increase in the outright purchases of long-term JGBs by the BOJ would have increased their price, lowered their interest rate and subsequently lowered their yield. In the latter stages of quantitative easing, with demand for increased CABS stabilising in 2004 and subsequently falling after April 2006, the price of future JGBs would have come under considerable downward pressures leading to possible rises in the yields on future JGBs. This effect could have been magnified in the latter stages of 2005 and in early 2006 due to inflationary expectations and expectations of possible interest rate hikes following the imminent withdrawal of the BOJ's QEP strategy.[10] *A priori,* therefore, the relationship between CABS and YIELDS is expected to be a negative one.

3.2 DATA

The data used in this study consists of 105 monthly observations spanning the period between April 1998 and December 2006, compiled by the Bank of Japan and the OECD. The dataset time period incorporates both the BOJ's quantitative easing policy - carried out between March 2001 and April 2006 – and Japan's zero interest rate period (April 1999 to April 2006, with a six-month interlude between August 2000 and March 2001). The data and the respective variable diagrams can be seen in Appendix 2.

[10] Throughout late 2005 and early 2006 BOJ officials made no secret of their plans to bring to a halt the BOJ's QEP strategy. The withdrawal of QEP in April 2006 was in fact highly anticipated, as was the subsequent interest rate hike in July 2006.

The following sections review the econometric tests conducted on the data and models in the light of the susceptibility of the time-series data to problems of nonstationarity and serial correlation.

3.3 CORRELOGRAM TESTS

Correlogram analysis is a principal diagnostic tool for investigating issues of nonstationarity in time-series data. A time-series is said to be stationary when its mean and variance do not vary systematically over time. Economic time-series exhibiting systematic trends and variations are highly susceptible to problems of nonstationarity, the presence of which may significantly compromise the validity of econometric analysis. Preliminary visual tests on the data relating to each of the four variables used in this study revealed significant eye-ball evidence of nonstationarity, particularly with respect to the M2+CDS variable.[11] In spite of having already decided to use the first differences of the data for the purposes of this study, the variables were still subjected to correlogram tests with respect to both level and first difference analysis (shown in Appendix 3).

Level correlograms revealed significant evidence of nonstationarity in the form of a linear decline of each of the variables' Autocorrelation (AC) coefficients. Spikes were also observed among a significant number of Partial Autocorrelation (PAC)

[11] Kimura et al (2002) point towards M2+CDs growing at a rate of around 3% per annum.

coefficients, particularly at Lag 1. First difference correlograms showed no linear decline in the AC coefficients, though significant spikes were found in both the AC and PAC coefficients. The results of first difference correlograms showed significant improvement over their level counterparts, though the presence of significant spikes made clear the case for ARMA term inclusion. Further stationarity tests were conducted, however, on both absolute levels and first difference data levels in order to confirm or reject the presence of stationarity.

3.4 UNIT ROOT TESTS

Unit root testing checks for stationarity in time-series data by regressing observations against their lagged values. The variables used in this study were tested for stationarity using the Augmented Dickey-Fuller (ADF) Tests. The methodology of ADF tests differs from conventional Dickey-Fuller (DF) tests in that the former method assumes the error term u_t to be correlated, and hence adds lagged values of the dependant variable to the unit root analysis carried out in the DF test. ADF tests were carried out on both the level (Appendix 4) and first difference of the data samples (Appendix 5), with each time-series analysed for a constant, as well as a constant and a linear trend. The results of the ADF tests confirmed the presence of nonstationarity in the M2+CDS, CABS, and YIELDS variables. Unit root testing with respect to the RATES variable rejected the null hypothesis of serial correlation at the 95% probability level but not at the 99% level.

Subsequent testing was carried out in order to check for Difference-Stationary Processes (DSP) and Trend-Stationary Processes (TSP). Checking for DSP entails conducting unit root tests on the first differences of the data in question, whereas TSP testing consists of plotting the absolute levels of the data against a time trend. The results of DSP testing (Appendix 5) confirmed all four variables to be I (1) and hence having stationary first differences. TSP testing on the other hand (Appendix 6) showed a significant time trend with respect to the M2+CDS, CABS and YIELDS variables but not the RATES variable.

The overall picture which emerged from both correlogram and unit root testing confirmed *a priori* expectations of significant stationarity in the dataset being used. It was therefore decided to use first differences for all four I (1) variables. Having said that, the absolute data levels were tested for cointegration in order to exhaust any possibility of cointegrating relationships between the dependant and CABS variables.

3.5 COINTEGRATION TESTS

Regressions composed of nonstationary time-series variables are highly susceptible to so-called spurious relationships which may at first glance look robust but are in reality false representations of possible correlation between variables. Some nonstationary time-series variables however may indeed share an actual long-term non-spurious (or equilibrium) relationship, in which case they are said to be cointegrated. Cointegrated regressions offer valuable insights into the non-spurious relationship between certain nonstationary economic time series. Popular cointegration testing methods include the Engle-Granger (EG) test and the Cointegrating Regression Durbin-Watson (CRDW) test. The EG test applies unit root testing to the residuals of regressions suspected to be cointegrated, whereas the CRDW test compares the Durbin-Watson statistic of the regression under study to critical values compiled by Sargan and Bhargava (1983).

EG tests were conducted with respect to the residuals derived from the following models (Appendix 7):

a) M2CDS versus CABS;
b) RATES versus CABS;
c) YIELDS versus CABS

The critical τ EG values were -1.59 (Model (a)), -2.91 (Model (b)), and -3.38 (Model (c)). The 1% Engle-Granger critical value of -2.5899 eliminates the possibility of cointegration with respect to Model (a) but finds evidence of possible (albeit slight) cointegration with respect to Model (b) and Model (c). It is important to note, however, that the results of the EG test with respect to Models (b) and (c) must not be taken as automatic proof of cointegration due to the lack of resolute certainty with respect to the nonstationarity of both RATES and YIELDS variables.

The results of the CRDW test (Appendix 7) confirm doubts as to any significant cointegration by failing to provide significant evidence of cointegration with respect to all three models. The Durbin-Watson values of 0.284 (Model (a)), 0.276 (Model (b)), and 0.398 (Model (c)) all fall very close to the 1%, 5%, and 10% CRDW critical values (0.511, 0.386, and 0.322). This finding calls for a rejection of significant cointegration in all three models.

Having carried out the necessary tests with respect to both absolute and first difference data levels, it is now proposed to focus on initial model testing on Equations 3.1.1, 3.1.2, and 3.1.3. The implications of the following tests are crucial in deriving the final ARIMA Equations used to analyse the effects of QEP, and are thus an integral part of the explanation pertaining to the models used in this study.

3.6 MODEL TESTING – EQUATION 3.1.1

Initial testing on regression Equation 3.1.1 (Appendix 8) revealed a number of pressing issues deserving significant consideration. Of particular importance is the high Durbin-Watson statistic of 2.76 confirming the presence of serial correlation (given the critical values of 2.31 and 2.43). It is to be noted that serial correlation is present in this model in spite of having used data first differences. The presence of serial correlation was confirmed through a Serial Correlation LM test which rejected the null hypothesis of no serial correlation. Correlogram tests on the regression itself also showed significant spikes in both the AC and PAC coefficients. This in turn called for a reformulation of the economic model to take into consideration autoregressive, moving average, and seasonal autoregressive terms in an effort aimed at understanding better the causes of movements in the dependant variable.

The model was modified using a trial and error process of adding and removing ARMA terms in tandem with correlogram and serial correlation LM testing in order to identify a suitable ARIMA estimation.[12] This process resulted in the following economic model, the results of which may be seen in the final results section (Section 4.1):

$$\Delta \text{Log (M2CDS)} = \beta_1 + \beta_2 \Delta \text{ Log (CABS)} + \beta_3 \text{ AR (7)} + \beta_4 \text{ AR (12)} + \beta_5 \text{ SAR (1)} + \beta_6 \text{ MA (2)} + \beta_7 \text{ MA (9)} + \beta_8 \text{ MA (12)} + u_t$$

(ARIMA Equation 3.1.1)

[12] The model used is defined as an ARIMA model since it makes use of all three ARIMA specifications: MA and AR terms, as well as the first differences of the original data set.

3.7 MODEL TESTING – EQUATION 3.1.2

Econometric analysis of Equation 3.1.2 (Appendix 9) revealed an insignificant explanatory variable, the presence of which severely compromised the validity of the model itself. The extremely low R^2 and insignificant F statistic – though highly worrying – are to be expected given the single-variable model specification. Serial correlation LM tests confirmed the presence of significant correlation, and correlogram analysis showed a number of significant AC and PAC coefficient spikes. This called for an immediate review of the model using AR, MA and SAR terms. Correlogram analysis and Serial Correlation LM tests were used as the basis for a trial and error method similar to that used with request to Equation 3.1.1 in a bid to find the best possible ARIMA specification.

This process resulted in the following economic model, the results of which are explained in Section 4.2:

$$\Delta \text{(RATES)} = \alpha_1 + \alpha_2 \Delta \text{Log (CABS)} + \alpha_3 \text{AR (2)} + \alpha_4 \text{AR (12)} + \alpha_7 \text{SAR (1)} + \alpha_8 \text{SAR (24)} + \alpha_9 \text{MA (2)} + u_t$$

(ARIMA Equation 3.1.2)

3.8 MODEL TESTING – EQUATION 3.1.3

Initial regression results with respect to Equation 3.1.3 (Appendix 10) revealed once again an insignificant explanatory variable. This resulted in an extremely low R^2 value and an insignificant F statistic (once again inevitable given the single-variable model specification used in model testing so far). Evidence of serial correlation was also found through the relevant Serial Correlation LM test and correlogram analysis. Once again it was decided to reformulate the model through the inclusion of ARMA specifications.

Equation 3.1.3 was remodelled using AR, MA and SAR terms, with Serial Correlation LM testing and correlogram analysis providing vital evidence with respect to the validity of the modifications made.

This process resulted in the following economic model, the results of which are explained in the Section 4.3:

$$\Delta\,(\text{YIELDs}) = \eta_1 + \eta_2 \Delta\,\text{Log}\,(\text{CABs}) + \eta_3\,\text{AR}(4) + \eta_4\,\text{AR}\,(5) + \eta_5\,\text{AR}\,(6) + \eta_6\,\text{AR}\,(26) + \eta_7\,\text{SAR}\,(12) + \eta_8\text{MA}\,(6) + u_t$$

(ARIMA Equation 3.1.3)

Chapter Four

EMPIRICAL RESULTS

This section expounds on the empirical results of the three models used in this study together with an analysis of their salient features. The models are presented individually together with a discussion of their economic implications.[13] The section concludes with a brief discussion of the conceptual and practical limitations of such a study, together with some recommendations on the matter.

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[13] Discussion of the results in Sections 4.1, 4.2 and 4.3 focusses on the relationship between the CABs explanatory variable and the dependant variable (M2CDS, RATES, and YIELDS respectively). A brief analysis of the ARMA terms contained in all three regressions is given in Section 4.4.

4.1 EMPIRICAL FINDINGS – ARIMA EQUATION 3.1.1

$$\Delta \text{Log (M2CDS)} = \beta_1 + \beta_2 \Delta \text{ Log (CABS)} + \beta_3 \text{ AR (7)} + \beta_4 \text{ AR (12)} + \beta_5 \text{ SAR (1)} + \beta_6 \text{ MA (2)} + \beta_7 \text{ MA (9)} + \beta_8 \text{ MA (12)} + u_t$$

Where:

M2CDS: M2 + Certificates of Deposit

CABS: Current Account Balances of Financial Institutions Held at the BOJ

AR (*t*): Autoregressive term with lag (*t*)

MA (*t*): Moving Average term with lag (*t*)

SAR (*t*): Seasonal Autoregressive term with lag (*t*)

Dependant Variable: DLog(M2CDS)

Sample (adjusted): June 1999 – December 2006

Number of Observations: 91 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	0.00176	0.00057	3.07917	0.00280
DLOG(CABS)	0.00385	0.00088	4.39344	0.00000
AR(7)	-0.20946	0.06203	-3.37677	0.00110
AR(12)	0.76236	0.05771	13.21053	0.00000
SAR(1)	-0.55349	0.09200	-6.01622	0.00000
MA(2)	-0.70236	0.05132	-13.68474	0.00000
MA(9)	0.38591	0.04584	8.41949	0.00000
MA(12)	0.13351	0.04084	3.26904	0.00160

R^2	0.856712	F-statistic		70.89303
Adjusted R^2	0.844627	Prob (F-statistic)		0.00000
Durbin-Watson stat	2.014702			

The econometric results of ARIMA Equation 3.1.1 are presented in Appendix 11 together with the relevant serial correlation LM test and correlogram analysis. The summary results shown above point to the explanatory variables being both individually and collectively significant in explaining changes in the dependant variable, and the high R^2 and adjusted R^2values (0.85 and 0.84 respectively) as well as the significance of the F-test are further proof of the robustness of the model results. Serial correlation tests carried out on the model reject the presence of serial correlation, and correlogram analysis on the regression itself shows significantly decreased AC and PAC coefficient spikes.

Further analysis with respect to the CABS explanatory variable is pertinent in order to consider the economic implications of the regression results. The latter variable - the proxy used for quantitative easing - is found to have a significant positive, albeit small, effect on the M2CDS variable. As the model shows, an increase of 1% in the rate of change in the CABS variable is expected to bring about an increase of 0.003% in changes in M2CDS *ceteris paribus*. The nature of this relationship as shown by the regression results confirms two principal – and possibly paradoxical – *a priori* expectations: firstly, that expansions in a country's monetary base do have positive effects on a country's economic indicators; and secondly, that the impact of the BOJ's expansionary QEP framework seems to have been somewhat limited in terms of its direct macroeconomic effect on the Japanese economy. The partial slope coefficient value implies that the first difference in CABS would have had to be incremented by

125% for Japanese M2CDs to have grown by at least 0.5% in a one month period *ceteris paribus.*[14] CABS increases of such a magnitude were few and far between however, as analysis of CABS movements shows: out of 103 first difference observations, 83 of these are positive or negative increments of less than 25%; only 8 observations are positive increments of more than 25%, with the remaining 11 observations being negative increments greater than 25%.

This point raises a number of questions about the direct macro-economic effects of the Bank of Japan's QEP strategy, and throws doubt over the BOJ's original intentions. Did the BOJ envisage its QEP framework as a direct stimulatory policy instrument? Or was it intended rather as an indirect signalling effect designed to influence the economy through the policy duration effect? The statistically significant though small co-efficient seems more adept at explaining the latter rather than the former. Though there is little way of knowing whether the limited effects of CABS expansion on M2CDS growth stemmed from the direct success of the policy duration effect or from the failure of an originally intended quasi-Friedman Helicopter Drop, the findings of this model seem to confirm the arguments of those who look at quantitative easing not as a direct stimulatory tool but rather as a signalling instrument intended to shape people's expectations of positive economic change through an illustration of a central bank's resolve in keeping the official interest rate at its zero level.

[14] Though a growth rate of 0.5% in one month might seem excessive given an M2CDs annual growth rate of 3%, the theory pertaining to unconventional monetary expansions nonetheless advises in favour of sudden, large-scale injections of liquidity rather than protracted monetary expansions.

Given the findings of this model, therefore, it may be rightly argued that monetary expansions intended to serve as a direct positive economic shock – as opposed to policies intended to function through the policy duration effect – should be of a severe magnitude, carried out promptly and in a somewhat unanticipated manner.[15] Propelling the economy out of deflationary scenarios through the use of extensive and unanticipated monetary expansions entails precise, wide-ranging, and decisive policies. Having said that, however, this does not in any way dismiss the positive effects of more accommodating policies designed to function through the policy duration effect. The results of this model prove that such expansions can still serve in stimulating positive macroeconomic pressures in an economy. This may indeed offer some solace to the more risk-averse central banker wary of helicopter drops or other extreme measures!

[15] For a good idea of how liquidity enhancing monetary expansions should be carried out, look no further than Friedman's use of the *helicopter* analogy: sudden, decisive, and wide-ranging.

4.2 EMPIRICAL FINDINGS – ARIMA EQUATION 3.1.2

$$\Delta \text{ (RATES)} = \alpha_1 + \alpha_2 \Delta \text{ Log (CABS)} + \alpha_3 \text{ AR (2)} + \alpha_4 \text{ AR (12)} + \alpha_7 \text{ SAR (1)} + \alpha_8 \text{ SAR (24)} + \alpha_9 \text{ MA (2)} + u_t$$

Where:

M2CDS: M2 + Certificates of Deposit

RATES: Japanese Interest Rates on Newly-Issued Ten-Year Government Bonds

AR (*t*): Autoregressive term with lag (*t*)

MA (*t*): Moving Average term with lag (*t*)

SAR (*t*): Seasonal Autoregressive term with lag (*t*)

Dependant Variable: D(RATES)

Sample (adjusted): May 2001 – December 2006

Number of Observations: 68 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	0.01202	0.00625	1.92210	0.05930
DLOG(CABS)	-0.20786	0.04457	-4.66388	0.00000
AR(2)	0.65923	0.09912	6.65106	0.00000
AR(12)	-0.10664	0.09060	-1.17710	0.24370
SAR(1)	0.19243	0.11900	1.61710	0.11100
SAR(24)	0.25099	0.10170	2.46807	0.01640
MA(2)	-0.96362	0.03179	-30.30968	0.00000

R^2	0.309089	F-statistic		4.548205
Adjusted R^2	0.241131	Prob (F-statistic)		0.00071
Durbin-Watson stat	1.950846			

Initial regression results with respect to Equation 3.1.2 had generated an insignificant CABS slope coefficient, prompting the reformulation of the model through ARMA specifications in the hope of achieving a better overall regression analysis of the effects of QEP on Japanese long-term interest rates. The results of ARIMA Equation 3.1.2 shown in Appendix 12 – a summary of which is shown above – are characterised by statistically significant explanatory variables and satisfactory correlogram analysis with respect to AC and PAC spikes. Serial correlation LM tests show no significant evidence of serial correlation, and the R^2 value of 0.30 is acceptable given the relatively specific nature of the economic model itself. The statistical significance of the CABS explanatory variable is of particular importance given the previous insignificant CABS variable result shown in initial Equation 3.1.2. The latter variable shows a negative relationship between CABS and Japanese long-term interest rates on newly-issued ten-year government bonds, and the partial slope coefficient of -0.208 implies that a 1% rise in CABS brings about a fall of 0.2% in interest rates. This does confirm *a priori* expectations of a negative relationship between movements in CABS and changes in Japanese long-term interest rates, though further consideration of this partial slope coefficient is pertinent in order to analyse better the relationship between these two variables.

The negative relationship between QEP-induced monetary expansions and Japanese long-term interest rates is assumed to be based on the underlying economic tenet behind conventional open market operations, even when such operations are carried out with respect to longer-term government securities. Increases in outright purchases of government bonds by monetary authorities implies upward pressures on prices and, hence, lower interest rates. In the Japanese scenario this would have been particularly apparent during the initial stages of quantitative easing, when CABS growth rates experienced very high increments. The rapid expansion of Japan's monetary base – financed through outright purchase of long-term Japanese Government Bonds (JGBs) – is assumed to have been the primary reason for the downward trend in JGB long-term bond interest rates, which fell from 1.3% in April 2004 to 0.5% in May 2003 (as shown in Appendix 2: Figure 2.4). CABS increases throughout this period, however, were far larger than those which would have been needed – according to the partial slope coefficient aforementioned – to bring rates down by 0.8%. The question which begs to be asked however – given the massive overall CABS increase - is the following: why did long-term interest rates not fall further than they actually did?

This question is based on a rather simplistic view of the relationship between CABS and the RATES variable. Analysis of CABS figures shows that sudden increments in CABS are more often than not followed by sharp falls, with the result that pressures on the long-term interest rate in one month would have been mitigated the following month. The relationship between the RATES variable and the highly volatile CABS variable, therefore, would have been much more stable in the long-run than during the short-run. Moreover, one has to bear in mind that policy decisions with respect to the long-term interest rates on newly-issued ten-year JGBs would have considered not simply the effects of CABS in that particular month but would have entailed a rather more holistic long-term view of the overall economic scenario.

It is to be noted that the negative relationship between the CABS and the interest rates on newly-issued ten-year government bonds shown in ARIMA Equation 3.1.2 would have been perfectly complimentary to the QEP's original objectives: enhancing broad liquidity through long-term securities purchases, inducing falls in long-term interest rates at a time when the short-term interest rate was at its zero bound level. Moreover, movements in CABS and Japanese long-term interest rates immediately following the withdrawal of quantitative easing confirm the negative relationship between the two variables, as shown by rises in long-term interest rates between June 2006 and December 2006, which appear to be negatively related to the rapid fall in CABS levels.

4.3 EMPIRICAL FINDINGS – ARIMA EQUATION 3.1.3

$$\Delta\,(\text{YIELDs}) = \eta_1 + \eta_2 \Delta\,\text{Log}\,(\text{CABs}) + \eta_3\,\text{AR}(4) + \eta_4\,\text{AR}\,(5) + \eta_5\,\text{AR}\,(6) + \eta_6\,\text{AR}\,(26) + \eta_7\,\text{SAR}\,(12) + \eta_8\text{MA}\,(6) + u_t$$

Where:

M2CDS: M2 + Certificates of Deposit

YIELDS: Yields on Ten-Year JGB future contracts listed on the TSE

AR (*t*): Autoregressive term with lag (*t*)

MA (*t*): Moving Average term with lag (*t*)

SAR (*t*): Seasonal Autoregressive term with lag (*t*)

Dependant Variable: D(YIELDS)

Sample (adjusted): July 2001 – December 2006

Number of Observations: 66 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	0.00474	0.00193	2.45744	0.01700
DLOG(CABS)	-0.21175	0.03908	-5.41794	0.00000
AR(4)	-0.33279	0.07800	-4.26660	0.00010
AR(5)	-0.20473	0.05477	-3.73817	0.00040
AR(6)	0.53228	0.09280	5.73615	0.00000
AR(26)	-0.22457	0.06642	-3.38102	0.00130
SAR(12)	-0.38561	0.12301	-3.13484	0.00270
MA(6)	-0.94704	0.02866	-33.04342	0.00000

R^2	0.441693	F-statistic		6.555077
Adjusted R^2	0.374311	Prob (F-statistic)		0.00001
Durbin-Watson stat	2.2561			

Initial testing of Equation 3.1.3 had resulted in an insignificant explanatory variable, compromising the intrinsic validity of the model. A summary of the results of ARIMA Equation 3.1.3 (Appendix 13) on the other hand presents significantly improved results compared to the initial equation, particularly with respect to the CABS explanatory variable. The explanatory variables are individually and collectively significant, and the R^2 and adjusted R^2 figures (0.44 and 0.37) and the significant F-test are further proof of the model's robustness. Moreover, serial correlation LM testing and correlogram analysis show no significant signs of serial correlation. All in all, the regression results not only make for an interesting analysis of the effects of QEP on the yields on ten-year government bond future contracts traded on the Tokyo Stock Exchange, but are also important, given that they confirm the results of ARIMA Equation 3.1.2, built on the same explanatory variable and on a similar, though not identical, dependant variable.

The partial slope coefficient with respect to the CABs variable (-0.211) implies that a 1% rise in the rate of change in CABs brings about a negative 0.211% change in the rate of change of yields on ten-year government bond future contracts traded on the Tokyo Stock Exchange *ceteris paribus*. Downward pressure on bond future yields implies upward pressure on bond future prices, downward pressure on interest rates on bond futures or both phenomena moving in tandem. Though there may be a plethora of reasons for any of the abovementioned movements in rates and prices – particularly in highly-sensitive and high-volume derivatives markets such as the TSE – an analysis of possible explanations with respect to the overall rising yields is in order.

The author's hypothesis about the negative sign exhibited by the CABs co-efficient is very similar to the rationale with respect to the relationship shown by ARIMA Equation 3.1.2. In the initial stages of QEP, outright purchases of long-term JGBs would have led to increases in their price and a fall in long-term interest rates, reducing the attractiveness of future bond purchases in the eyes of investors and the general public. As BOJ outright purchases of JGB long-term bonds stabilised however, demand for JGBs levelled off, inducing pressures on bond prices to fall, and leading to increases in long-term interest rates (in line with the regression results of ARIMA Equation 3.1.2). The negative relationship between CABS and YIELDS is also apparent at the end of the BOJ's QEP strategy. Analysis of the relevant CABS and YIELDS variable data plots (shown in Appendix 2: Figures 2.2 and 2.5) shows that the rapid fall in CABS in the months following April 2006 is accompanied by a rise in yields on government bond future contracts, implying falls in the price of bond future contracts, and increases in their interest rate. Within the futures market, the effect of rising long-term interest rates on bond yields would have been particularly emphasised by the sudden falls in JGBs prices stemming from popular expectations that the BOJ would soon conclude QEP and sell off all its stocks of acquired JGBs.[16] Expectations of future interest rate hikes and possible inflationary pressures would have further contributed to upward pressures on the yield on JGB futures contracts, further reinforcing the negative relationship between falling CABS and rising yields.

[16] Towards the final few months of quantitative easing there was indeed increased speculation of an imminent withdrawal of QEP coupled with high expectations of possible interest rate hikes, prompting possible sudden falls in the prices for bond future contracts.

4.4 ARIMA IMPLICATIONS

ARIMA Equations 3.1.1, 3.1.2, and 3.1.3 are all characterised by the inclusion of auto-regressive moving average (ARMA) model specifications, including autoregressive (AR), moving average (MA) and seasonal autoregressive (SAR) terms.

The inclusion of ARMA terms in such a study is seen as serving two very important functions. The first of these relates to the obvious effects of ARMA inclusion with respect to the econometric robustness of the results, particularly the BLUE properties of the CABs partial slope coefficient. Comparison of the economic models before and after ARMA inclusion is testimony to the increased statistical significance of the CABs variable following ARMA reformulation, particularly in ARIMA Equations 3.1.2 and 3.1.3. A second important characteristic of ARMA term inclusion in such a study is that the AR, MA and SAR partial slope coefficients shed crucial light on the movement of changes in the dependant variables. This is particularly important in time-series studies characterised by variables which are highly susceptible to nonstationarity and random walk phenomena. ARMA coefficients give important insights into the movement of the dependant variables over time, and confirm *a priori* expectations that the dependant variables are influenced not only by their immediate one-period lag but by further lags, some of which exhibit high t-test values. ARMA term inclusion is therefore effective on two very important counts: reinforcing the robustness of the results with respect to the relationship between the dependant and principal explanatory variable and providing vital insights into the movement of the dependant variable over time.

4.5 LIMITATIONS AND RECOMMENDATIONS

Having analysed the results of the econometric models used in this study, it is now pertinent to consider a number of limitations and relevant recommendations that may be made with respect to the workings and findings of this study.

The principal limitation with respect to the dataset used is undoubtedly the limited time period available for post-quantitative easing analysis. The lack of observations in the aftermath of the BOJ's QEP policy provides a dearth of information at a time when economic analysis is likely to yield some very important findings relating to the effects of QEP. A number of pertinent questions remain, particularly those relating to the magnitude of the BOJ's reduction of its CABS stock, the rate of growth in M2CDS following the withdrawal of QEP and the extent of the Japanese economic recovery itself. [17] The obvious recommendation in this respect is to allow for a longer time period in which to analyse the effects of QEP, though it is the author's belief that extending the period of analysis would not result in significant alterations to the findings of this study *ceteris paribus*.

Recommendations are also in order with respect to the variables used in this study. The CABs variable is believed to have been the proper proxy for quantitative easing, since it captures the immediate effects of the BOJ's outright purchase long-term government

[17] In February 2007 deflation in Japan made a surprise reappearance, though the factors causing it were said to be related to events outside the Japanese economy, providing little cause for alarm.

securities. The RATES variable is also assumed to have been a correct proxy with respect to Japanese long-term interest rates. The M2CDS and YIELDS variables however do not command such instant recognition as perfect proxies for an analysis of the effects of QEP, particularly the variable relating to the yield on government bond future contracts traded on the TSE. Possible recommendations with respect to the M2CDS and YIELDS variables are considered in turn below.

The M2CDs variable was chosen due to the great importance it commands – particularly in BOJ circles - as an indicator of Japanese economic wellbeing. A list of possible alternatives to the M2CDs variable would most certainly include Japanese GDP growth, bank lending (domestic, commercial, and industrial), and investment expenditure and consumer spending. This last variable is seen by the author as the most suitable proxy from among the listed alternatives to M2CDs. Consideration would have to be given, however, with respect to any relevant time lags as well as adjustment for expenditures with regards to imports and Japanese foreign investment abroad.

Turning to the YIELDs variable used in Equation 3.1.3 and ARIMA Equation 3.1.3, a number of concerns spring to mind, in spite of the significant popularity of the Japanese futures market, particularly that pertaining to ten-year JGB futures. The principal concern with respect to this variable related to the two-way influence of prices and interest rates on the yields of JGB future contracts, making it difficult – though not impossible - to interpret exactly what was behind movements in JGB yields. Another concern related to the lack of readily available data on the prices – rather than the yields – of ten-year JGBs traded on the TSE. Information pertaining to government bond future contract prices might have made for an interesting proxy for the effects of the QEP strategy on Japanese expectations of future inflation and interest rate movements, though it is believed that the YIELDS variable itself does a better job than the futures spot price in incorporating such expectations.

Having briefly analysed the implications of ARMA term inclusion with respect to the economic models used in this study, it would be pertinent to consider further implementation of ARIMA modelling to the models in question, particularly the study pertaining to Japanese M2CDs. Though the results of all three equations do substantiate the author's trial and error ARMA inclusion process, there is admittedly much that may be done through more advanced economic modelling in order to achieve deeper insights into the behaviour of the variables in question.

A similar recommendation relates to including the effect of lags with respect to the CABS variable, in order to assess the effect on the dependant variables of previous increments in the level of CABS. In spite of a significant *a priori* belief that CABS increments would have been transmitted very quickly through the monetary policy transmission mechanism, it would still be pertinent to note any possible significant effects of lagged CABS changes – or possibly the cumulative CABS level at time *t*.

A further recommendation relates to the use of dummy variables in order to identify possible signalling effects of the BOJ's numerous policies at work during the period in question. The use of dummies is considered with respect to the BOJ's Zero Interest Rate Policy (ZIRP – April 1999 to February 2001), its QEP framework (March 2001 to April 2006), and the period encompassing the end of QEP to the BOJ's subsequent interest rate rises. The introduction of dummy variables would ideally form part of a more comprehensive analysis of QEP based on a longer time period in order to lend strength to any significant findings with respect to the signalling component of the policy duration effect.

Chapter Five

CONCLUSION

This dissertation has attempted to empirically analyse the effects of the Bank of Japan's anti-deflationary quantitative easing policy carried out between March 2001 and April 2006. In doing so, this study has also reviewed the zero bound to interest rates, defined as the primary constraint to the effectiveness of conventional monetary policy at the interest rate floor. The realm of monetary policy beyond this zero bound is confined to a number of unconventional strategies, many of which are concerned with expansions of a country's monetary base in an attempt at enhancing broad liquidity. The Bank of Japan's quantitative easing policy remains to this day the only circumstance in which such monetary policies have been tried and tested.

Has the BOJ's QEP strategy been vindicated however? There is an encouraging mood in Japan, spurred on by modest economic growth, confident *Tankan* survey results, and more importantly, evidence of inflationary pressures at work once again. How much of Japan's recovery can really be attributed to the Bank of Japan's QEP strategy however? The findings of this study provide significant, though very limited evidence, of QEP having single-handedly turned the tide in Japan's protracted decade-long struggle against deflation, corroborating similar findings in related studies. There is evidence, however, of QEP having stabilised the Japanese banking sector by providing ample amounts of excess liquidity, allowing Japanese financial institutions to tentatively clean up their act and provide for a more transparent and equitable banking system, particularly in the area of non-performing loans. The positive relationship between the Bank of Japan's monetary expansions and Japanese M2 + Certificates of Deposits – notwithstanding persistent consumer pessimism – is proof of the Bank of Japan's determined stance in supporting the economy, typified by the policy duration effect: the BOJ's commitment to resolutely maintain its QEP strategy till Japan's economy registered inflationary pressures.

Analysis of the effects of QEP on Japanese long-term interest rates on newly-issued ten-year Japanese government bonds (JGBs) confirms the positive effects of QEP in lowering long-term interest rates. The expansion in Japan's monetary base was, therefore, successful in lowering interest rates at a time when the traditional tool of monetary policy – the short-term interest rate – was regarded as having been effectively rendered useless as a result of Japan's protracted liquidity trap scenario. This confirms that central banks need *not* consider themselves helpless in the face of significant obstacles to the effectiveness of conventional monetary policy instruments.

Furthermore, analysis of the relationship between QEP and the yields on long-term JGB future contracts listed on the Tokyo Stock Exchange confirms the negative relationship between BOJ-induced monetary expansions and long-term interest rates. Falls in long-term interest rates would have reduced the attractiveness of long-term securities, encouraging investment and consumer spending. Moreover, the presence of the negative relationship between CABS and long-term interest rates in high-volume markets such as the TSE implies that the effects of the BOJ's monetary expansions managed to successfully make their way through the monetary policy transmission mechanism. This finding puts further weight to the indirect though forceful role of QEP in fostering positive trends in Japan's tentative move towards normalised inflationary expectations.

To conclude, therefore, it would be pertinent to note a final question with respect to the findings of this study: what lessons does the Japanese experience hold for modern economies? Traditional economic thought itself imparts little knowledge about deflation other than a very conceptual review of its basic tenets. The Japanese scenario, however, provides ample material for discussion about how to prevent deflation and how best to cure it before it causes ruinous damage to an economy. More importantly, however, the Japanese experience holds valuable lessons for Western economies captivated by the prospect of ultra-low inflation and doing their utmost to achieve such a scenario with apparently little regard for the dangers inherent in very low inflation rates. It is true that low inflation has always been typical of economic downturns, a common feature of many economies' business cycles. The advent of globalisation however has led to further falls in prices across a wide range of goods and services, dampening in some countries the inflationary effects of economic booms. Moreover, increased capital and labour mobility will in future persist in keeping price increases at low levels. Though the risk of countries falling into cataclysmic deflationary spirals remains significantly low, the vulnerability of countries experiencing deflationary episodes is still ever present, particularly in the European Union, where even the mildest deflationary scenario might have severe repercussions across the whole continent. The first lesson imparted by the Japanese experience, therefore, is that very mild deflation is far more calamitous than even moderate inflation, and that the risks of stumbling into a liquidity trap increase exponentially as inflation rates fall. Central bankers intent on minimising excessive price fluctuations must consider not only the widely-known implications of high inflation rates but also the potential risks inherent in minimal price increases, including possible deflationary pressures creeping into an economy.

The second lesson imparted by the Japanese scenario relates to the effectiveness of the policy duration effect, defined as the macroeconomic signalling effect transmitted through an institution's resolve in maintaining the implementation of a particular policy till its primary objective is reached. Effective policy may not necessarily entail extensive actions; on the other hand, credibility coupled with resolved commitment is enough to provide for positive macroeconomic outcomes. The Japanese scenario might not be an example of a direct and decisive anti-deflationary monetary expansion. It does, however, prove that the policy duration effect may indeed reap positive effects on an economy, albeit in a protracted and at times uncertain manner. This may very well disappoint supporters of unconventional policy instruments and helicopter drops, though it admittedly provides more than enough solace to the risk averse central banker intent on minimising the risks inherent in anti-deflationary monetary expansions carried out under a zero interest rate policy constraint.

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  "On a Roll", July 6th 2006.

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  "A First, Gentle Shake", April 27th, 2006.

  "After the Flood", March 9th 2006.

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  "Picking Itself Up", February 23rd 2006.

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  "Land of the Rising Price", December 14th 2005.

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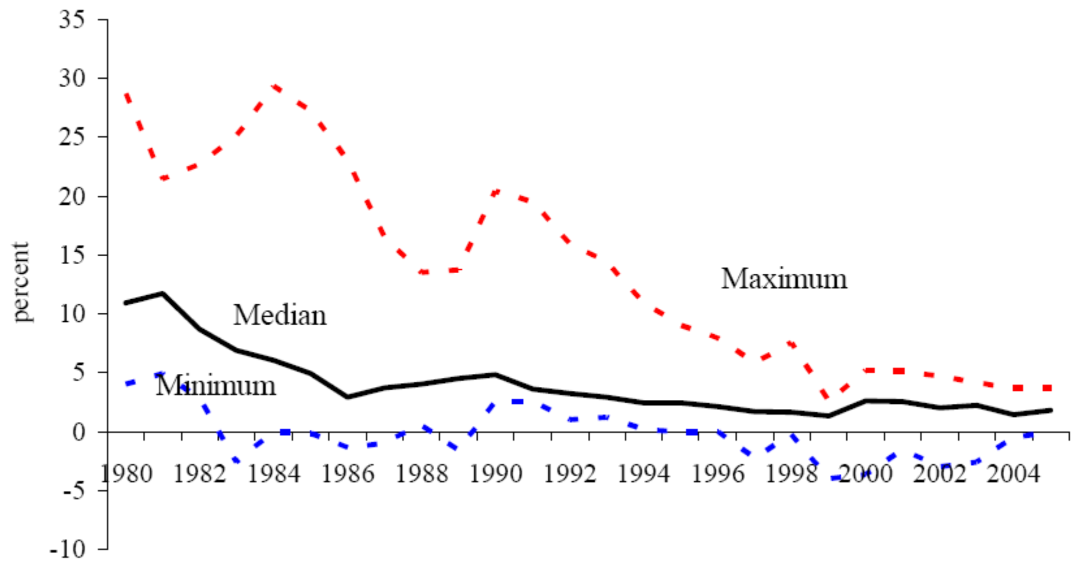
APPENDIX 1 - FIGURES AND TABLES

Figure 1: Consumer Price Inflation in Advanced Economies (Bernanke et al, 2004)



Source: International Monetary Fund, World Economic Outlook (April 2004); IMF definition of 28 advanced economies excluding Iceland and Israel.

Figure 2: Japanese Real GDP, CPI and Money Wage Growth (Buiter, 2003)

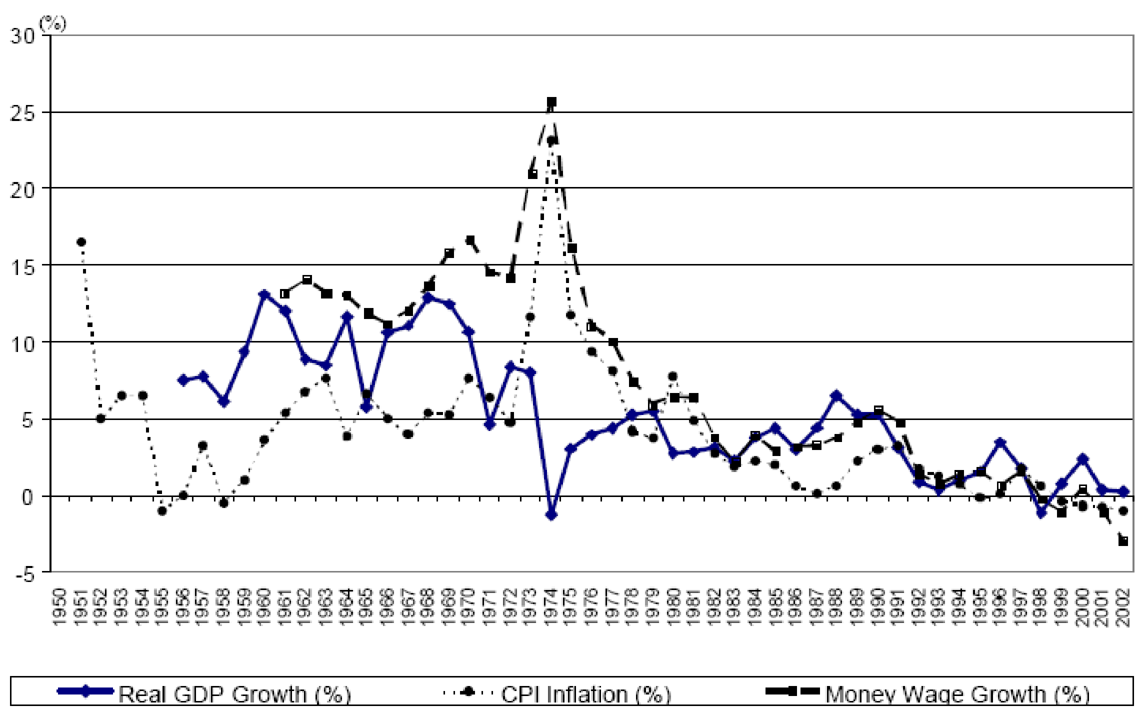


Figure 3: Japanese Real GDP and CPI (Oda and Ueda, 2005)

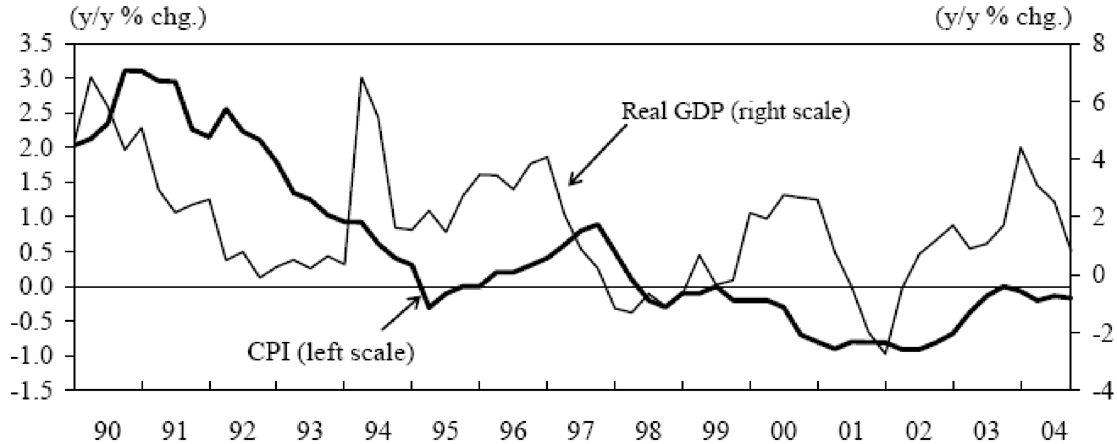


Figure 4: Japanese Monetary base, Money Supply, and Nominal GDP

(Oda and Ueda, 2005)

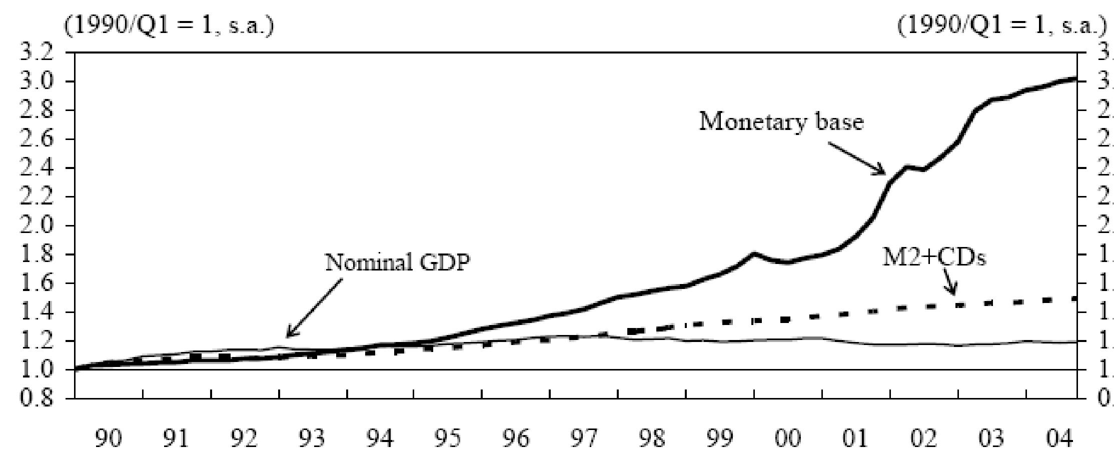


Figure 5: Current Account Balances Held at the BOJ (Maeda et al, 2005)

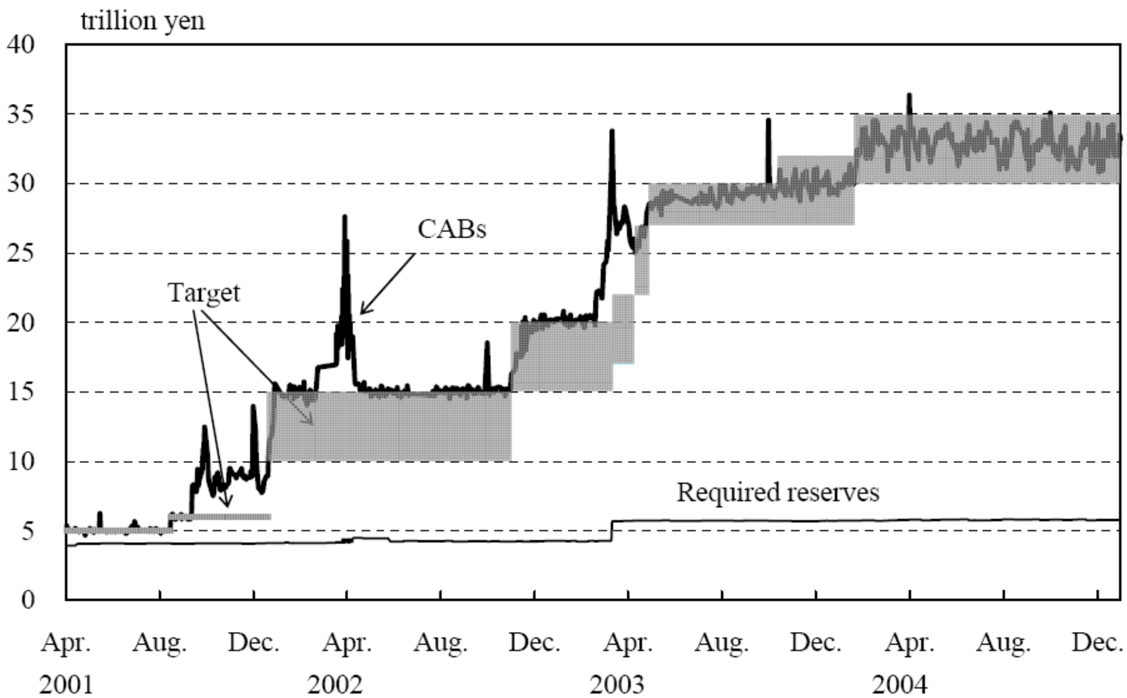


Figure 6: Number of Counterparties engaged in QEP (Maeda et al, 2005)

	Total			
		JGS-related	Outright purchases of bills	
			At all offices	At Head Office
City banks	7	7	7	7
Trust banks	7	2	7	6
Regional banks and regional banks II	72	1	72	3
Foreign banks	12	7	12	8
Securities firms	26	26	20	7
Shinkin banks	9	0	8	0
Tanshi companies (money market brokers)	3	3	3	3
Others	11	9	11	9
Total	144	52	137	40

Notes: 1. The figures are as of 2004.

Figure 7: Amount of Outright Purchases of JGBs (Maeda et al, 2005)

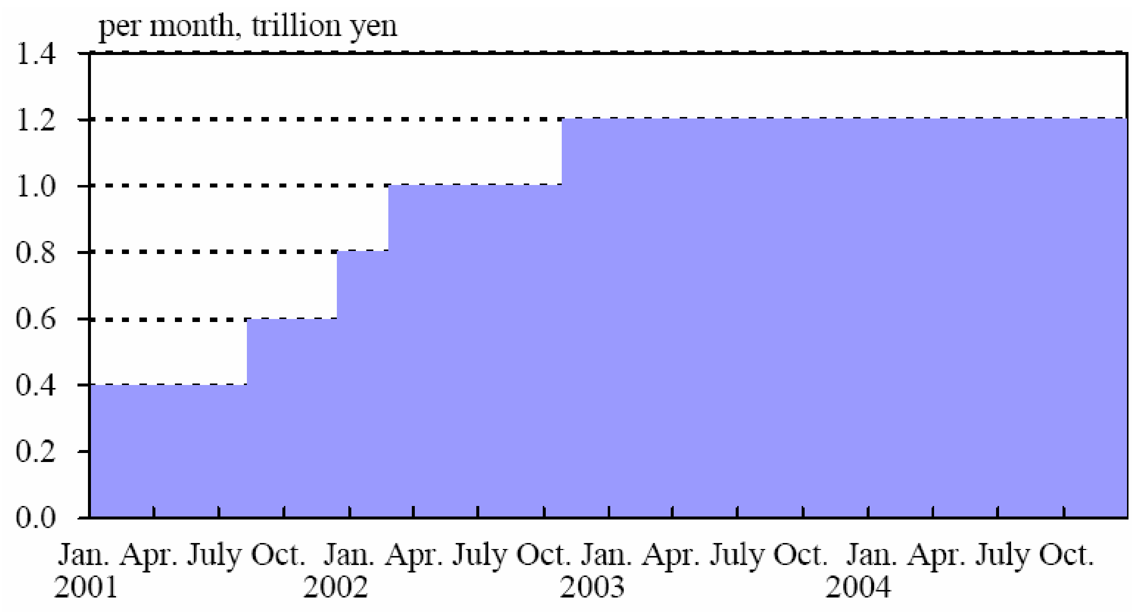
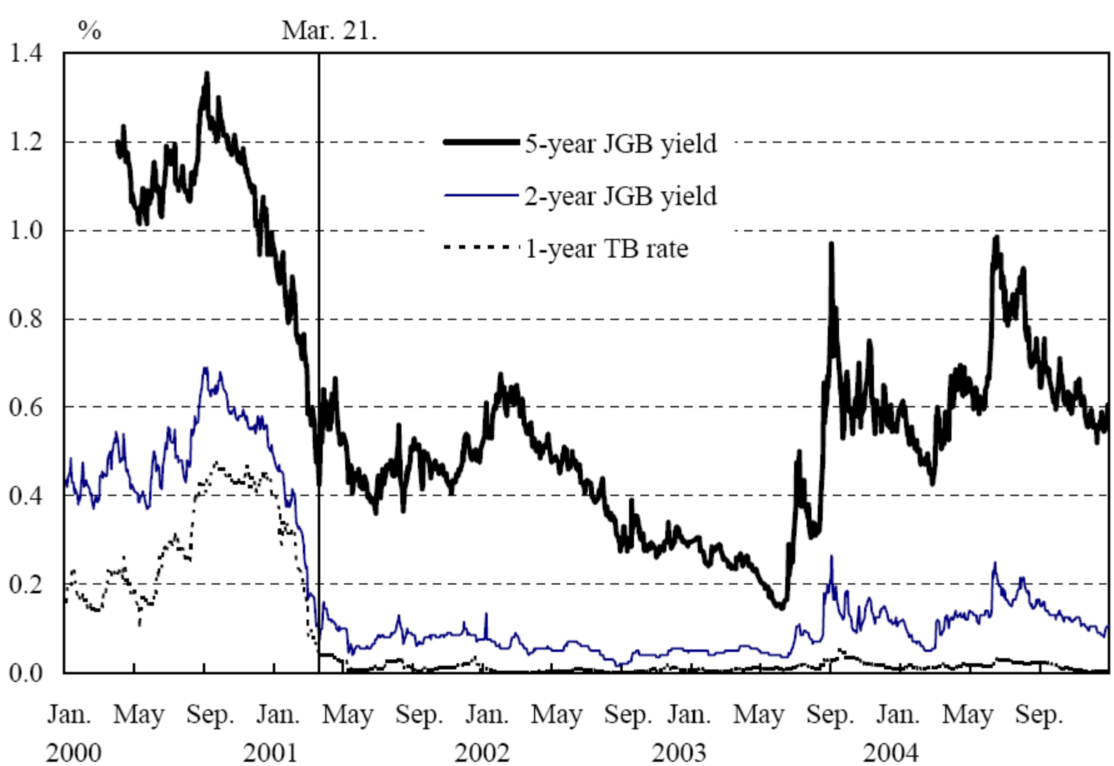


Figure 8: Yield Rates on Japanese Treasury Bills (TB) and Japanese Government Bonds (JGB) (Maeda et Al, 2005)



APPENDIX 2 – REGRESSION DATA AND DATA PLOTS

2.1 Data

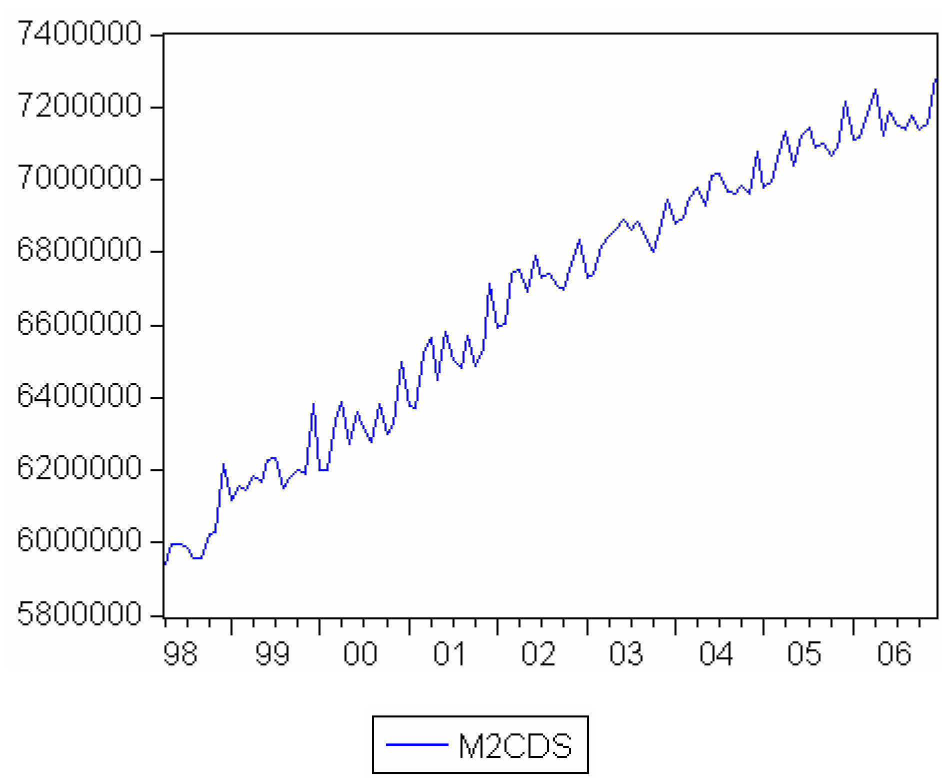
Year	*CABs*	*Yields*	*M2CDs*	*Rates*
	100 Million Yen	*%*	*100 Million Yen*	*%*
1998:04	39,614	2.181	5,939,343	1.867
1998:05	39,475	1.975	5,994,941	1.655
1998:06	40,492	2.057	5,998,149	1.54
1998:07	35,553	1.982	5,983,584	1.683
1998:08	41,571	1.808	5,959,439	1.502
1998:09	57,343	1.522	5,959,311	1.103
1998:10	37,118	1.538	6,020,853	0.879
1998:11	44,083	1.690	6,029,840	0.977
1998:12	43,780	2.509	6,214,936	1.488
1999:01	43,732	2.410	6,116,531	1.91
1999:02	46,305	2.213	6,153,414	2.117
1999:03	61,675	2.075	6,146,748	1.816
1999:04	42,735	1.831	6,185,383	1.563
1999:05	46,963	1.776	6,164,148	1.334
1999:06	46,632	2.379	6,227,500	1.632
1999:07	48,976	2.216	6,234,356	1.703
1999:08	48,534	2.405	6,151,611	1.878
1999:09	60,577	2.124	6,180,517	1.759
1999:10	49,484	2.220	6,202,029	1.692
1999:11	53,408	2.218	6,189,145	1.817
1999:12	233,859	2.047	6,380,106	1.767
2000:01	53,769	1.982	6,202,595	1.691
2000:02	148,741	2.231	6,202,671	1.796
2000:03	183,413	2.167	6,339,881	1.819
2000:04	54,004	2.084	6,386,872	1.74
2000:05	54,512	1.956	6,271,463	1.705
2000:06	51,803	2.052	6,361,902	1.664
2000:07	50,913	1.958	6,316,030	1.689
2000:08	50,241	2.122	6,275,459	1.75
2000:09	52,255	2.081	6,384,104	1.876
2000:10	40,451	1.999	6,297,371	1.815
2000:11	43,754	1.808	6,327,748	1.764
2000:12	68,270	1.860	6,498,631	1.624
2001:01	50,909	1.683	6,376,495	1.508
2001:02	46,790	1.562	6,369,684	1.415
2001:03	58,142	1.509	6,521,371	1.169
2001:04	50,671	1.495	6,561,997	1.315
2001:05	50,260	1.380	6,449,283	1.25
2001:06	57,058	1.375	6,581,678	1.152
2001:07	50,537	1.448	6,503,165	1.305
2001:08	59,293	1.444	6,480,642	1.343
2001:09	124,794	1.469	6,567,647	1.346

Year	CABs	Yields	M2CDs	Rates
	100 Million Yen	*%*	*100 Million Yen*	*%*
2001:10	95,268	1.379	6,485,176	1.363
2001:11	139,639	1.448	6,531,469	1.328
2001:12	156,153	1.575	6,712,768	1.334
2002:01	149,974	1.741	6,590,942	1.42
2002:02	146,277	1.681	6,604,835	1.501
2002:03	276,107	1.597	6,739,172	1.421
2002:04	189,886	1.541	6,749,189	1.394
2002:05	149,749	1.509	6,691,094	1.365
2002:06	150,532	1.505	6,789,555	1.328
2002:07	151,248	1.481	6,729,569	1.296
2002:08	152,276	1.323	6,742,096	1.255
2002:09	185,325	1.396	6,705,529	1.129
2002:10	162,012	1.269	6,698,849	1.095
2002:11	199,185	1.255	6,767,688	0.979
2002:12	195,625	1.262	6,835,938	0.975
2003:01	204,192	1.205	6,728,016	0.836
2003:02	202,234	1.173	6,740,619	0.828
2003:03	309,297	1.184	6,819,007	0.724
2003:04	260,111	1.142	6,846,126	0.663
2003:05	289,436	1.049	6,859,770	0.577
2003:06	289,315	1.302	6,888,988	0.529
2003:07	292,479	1.279	6,860,761	0.956
2003:08	291,163	1.644	6,884,145	1.406
2003:09	345,600	1.680	6,845,301	1.42
2003:10	298,360	1.682	6,803,024	1.437
2003:11	310,185	1.552	6,876,925	1.333
2003:12	300,307	1.606	6,947,090	1.33
2004:01	339,676	1.506	6,876,708	1.33
2004:02	330,731	1.427	6,895,225	1.211
2004:03	363,600	1.632	6,948,103	1.418
2004:04	321,517	1.649	6,980,147	1.52
2004:05	321,497	1.596	6,930,119	1.505
2004:06	337,339	1.843	7,008,390	1.807
2004:07	314,101	1.865	7,018,067	1.808
2004:08	329,885	1.623	6,964,483	1.588
2004:09	350,726	1.596	6,960,870	1.393
2004:10	318,820	1.581	6,985,039	1.483
2004:11	342,170	1.540	6,963,076	1.452
2004:12	331,784	1.564	7,075,527	1.397
2005:01	316,211	1.461	6,979,463	1.31
2005:02	331,024	1.578	6,994,203	1.419
2005:03	357,562	1.476	7,075,020	1.325
2005:04	317,807	1.387	7,133,867	1.257
2005:05	315,506	1.371	7,036,620	1.238
2005:06	335,895	1.331	7,120,601	1.143
2005:07	298,062	1.434	7,144,080	1.295
2005:08	331,925	1.459	7,085,968	1.365

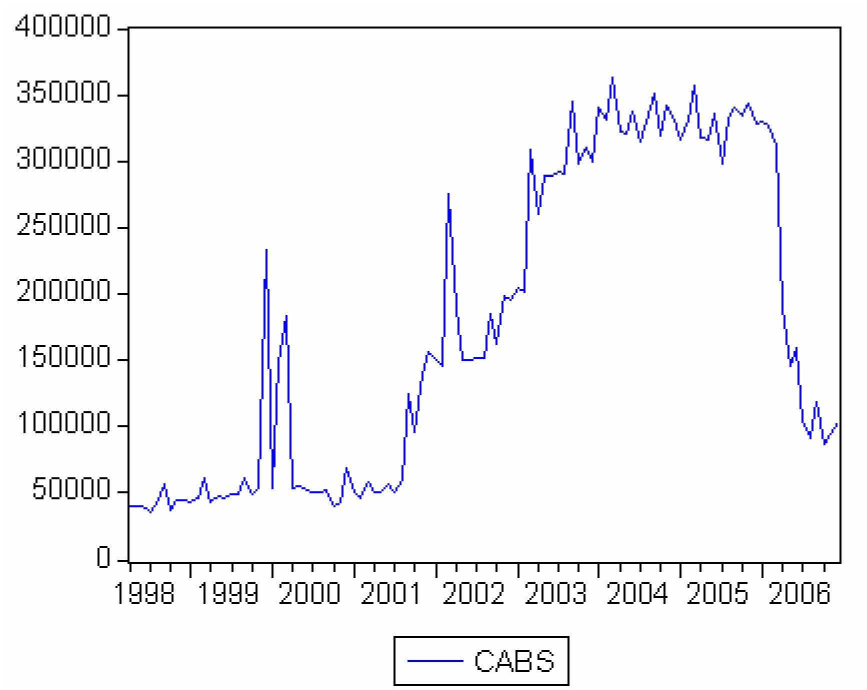
Year	CABs	Yields	M2CDs	Rates
	100 Million Yen	%	100 Million Yen	%
2005:09	341,066	1.623	7,099,996	1.45
2005:10	334,918	1.670	7,068,659	1.513
2005:11	343,499	1.560	7,087,320	1.454
2005:12	328,677	1.649	7,217,872	1.488
2006:01	329,323	1.696	7,108,854	1.547
2006:02	326,136	1.765	7,116,691	1.598
2006:03	312,015	1.988	7,184,353	1.759
2006:04	188,715	2.066	7,248,733	1.956
2006:05	146,137	1.970	7,120,767	1.849
2006:06	158,752	2.153	7,185,212	1.901
2006:07	104,985	2.121	7,151,300	1.927
2006:08	91,030	1.853	7,136,025	1.668
2006:09	117,944	1.869	7,178,220	1.628
2006:10	86,376	1.897	7,138,859	1.718
2006:11	94,252	1.843	7,152,336	1.69
2006:12	104,125	1.935	7,283,268	1.645

M2CDS, CABS, YIELDS: Bank of Japan RATES: OECD

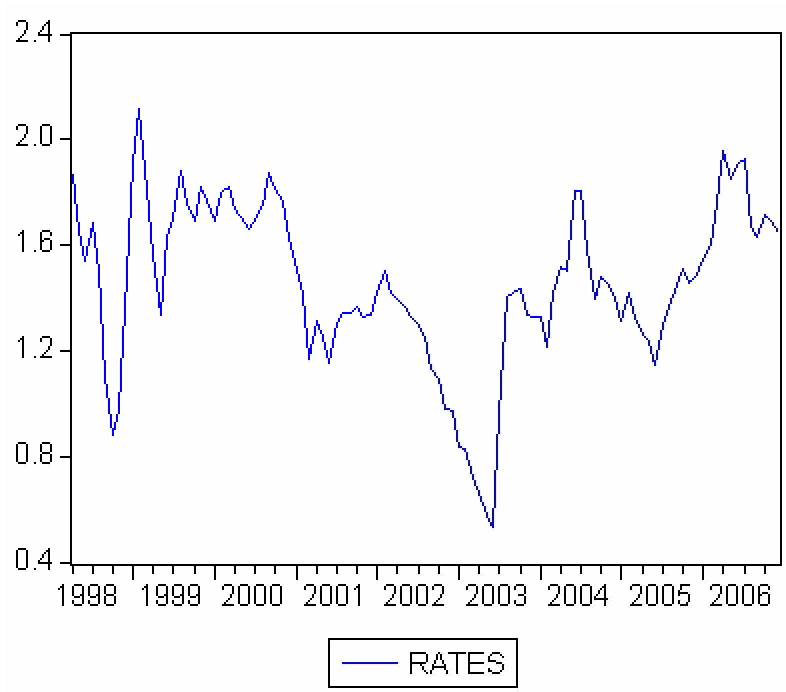
2.2 Data Plots – M2CDS (100 Million Yen)



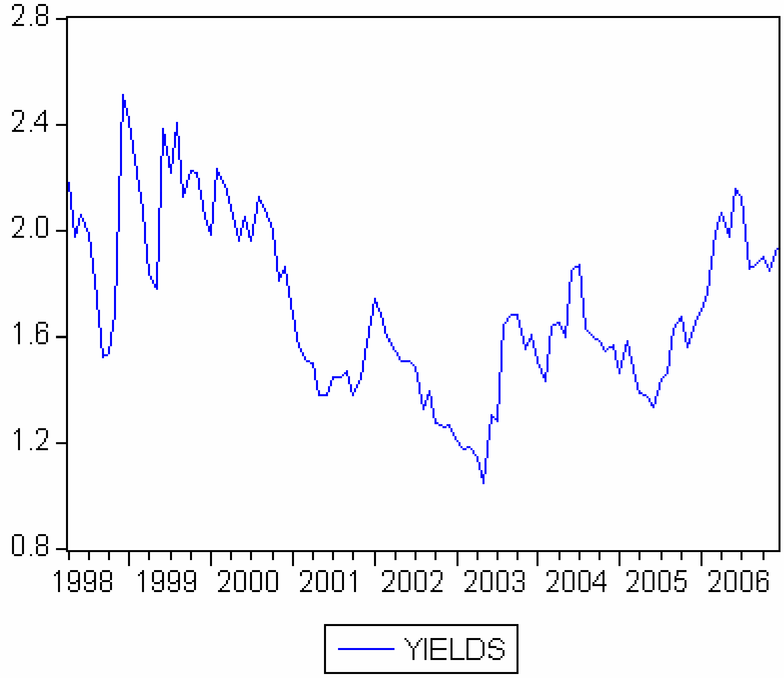
2.3 Data Plots – CABS (100 Million Yen)



2.4 Data Plots – RATES (%)



2.5 Data Plots – YIELDS (%)



APPENDIX 3 – CORRELOGRAM TESTS

3.1 Correlograms – Absolute Levels

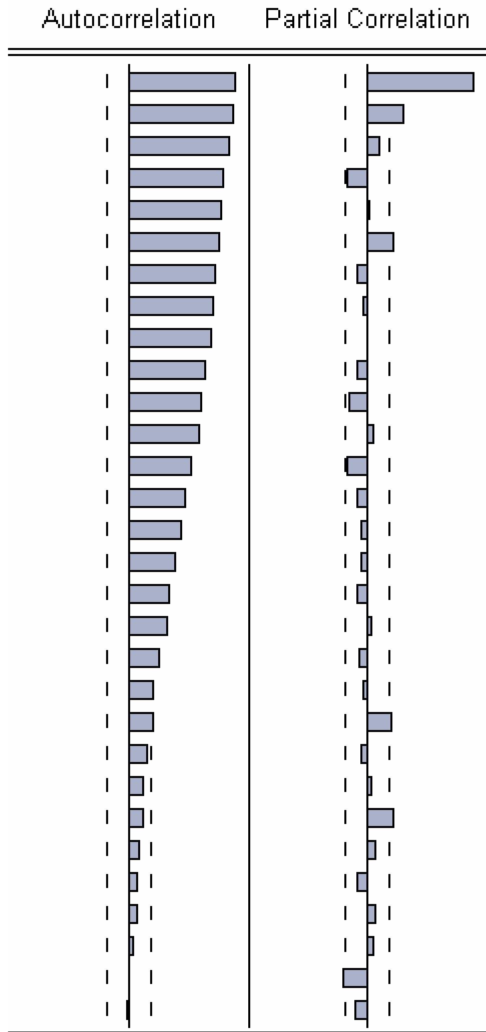
3.1.1 M2CDs Correlogram (30 lags, roughly one third of 105 observations)

Date: 03/15/07 Time: 13:36
Sample: 1998M04 2006M12
Included observations: 105

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.931	0.931	93.623	0.000
		2	0.888	0.162	179.69	0.000
		3	0.857	0.100	260.55	0.000
		4	0.808	-0.109	333.22	0.000
		5	0.757	-0.078	397.68	0.000
		6	0.721	0.053	456.76	0.000
		7	0.670	-0.103	508.16	0.000
		8	0.634	0.087	554.76	0.000
		9	0.603	0.021	597.32	0.000
		10	0.557	-0.093	634.00	0.000
		11	0.524	0.042	666.86	0.000
		12	0.506	0.079	697.80	0.000
		13	0.459	-0.153	723.54	0.000
		14	0.428	0.030	746.18	0.000
		15	0.405	0.011	766.62	0.000
		16	0.372	-0.009	784.10	0.000
		17	0.337	-0.063	798.56	0.000
		18	0.312	0.003	811.11	0.000
		19	0.277	-0.022	821.13	0.000
		20	0.255	0.036	829.70	0.000
		21	0.237	0.026	837.22	0.000
		22	0.202	-0.085	842.77	0.000
		23	0.180	0.020	847.23	0.000
		24	0.171	0.040	851.28	0.000
		25	0.144	-0.033	854.21	0.000
		26	0.126	0.000	856.46	0.000
		27	0.111	-0.031	858.22	0.000
		28	0.087	-0.028	859.34	0.000
		29	0.063	-0.051	859.92	0.000
		30	0.052	0.051	860.33	0.000

3.1.2 CABS Correlogram (30 lags, roughly one third of 105 observations)

Date: 03/15/07 Time: 13:32
Sample: 1998M04 2006M12
Included observations: 105



	AC	PAC	Q-Stat	Prob
1	0.925	0.925	92.397	0.000
2	0.901	0.313	180.88	0.000
3	0.876	0.112	265.48	0.000
4	0.825	-0.171	341.28	0.000
5	0.796	0.014	412.55	0.000
6	0.791	0.230	483.59	0.000
7	0.751	-0.093	548.25	0.000
8	0.731	-0.027	610.06	0.000
9	0.712	-0.003	669.40	0.000
10	0.668	-0.096	722.25	0.000
11	0.624	-0.157	768.76	0.000
12	0.601	0.052	812.47	0.000
13	0.539	-0.172	847.90	0.000
14	0.494	-0.087	878.01	0.000
15	0.455	-0.056	903.86	0.000
16	0.400	-0.050	924.07	0.000
17	0.349	-0.086	939.58	0.000
18	0.320	0.034	952.80	0.000
19	0.262	-0.070	961.76	0.000
20	0.219	-0.026	968.10	0.000
21	0.206	0.209	973.79	0.000
22	0.158	-0.045	977.17	0.000
23	0.128	0.040	979.40	0.000
24	0.131	0.225	981.77	0.000
25	0.097	0.068	983.10	0.000
26	0.068	-0.093	983.76	0.000
27	0.065	0.081	984.37	0.000
28	0.035	0.056	984.55	0.000
29	-0.006	-0.207	984.56	0.000
30	-0.018	-0.108	984.60	0.000

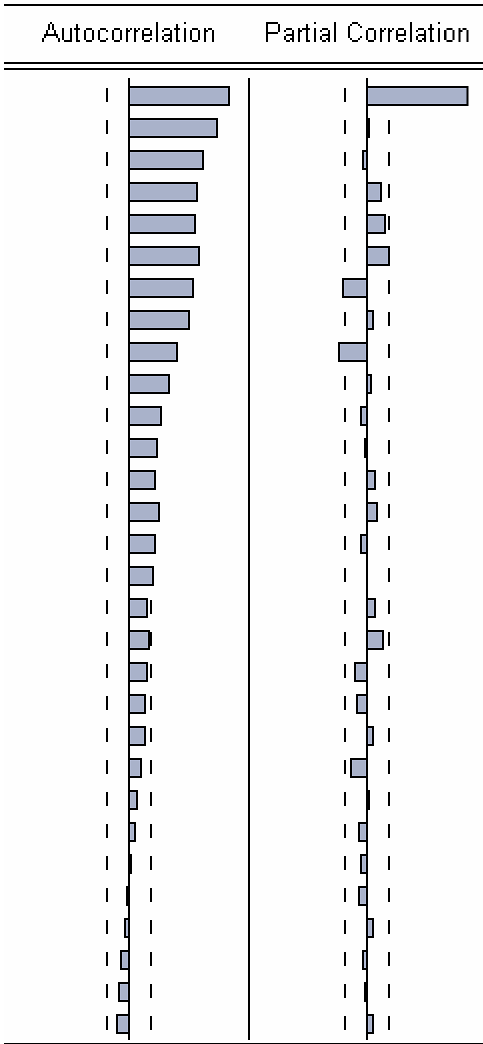
3.1.3 RATES Correlogram (30 lags, roughly one third of 105 observations)

Date: 04/29/07 Time: 16:41
Sample: 1998M04 2006M12
Included observations: 105

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.873	0.873	82.258	0.000
		2	0.680	-0.340	132.76	0.000
		3	0.521	0.105	162.68	0.000
		4	0.419	0.066	182.18	0.000
		5	0.384	0.155	198.72	0.000
		6	0.374	-0.006	214.59	0.000
		7	0.348	-0.044	228.51	0.000
		8	0.299	-0.031	238.88	0.000
		9	0.220	-0.101	244.53	0.000
		10	0.144	0.022	246.99	0.000
		11	0.072	-0.120	247.61	0.000
		12	0.012	-0.016	247.63	0.000
		13	-0.011	0.056	247.64	0.000
		14	-0.001	0.058	247.64	0.000
		15	-0.002	-0.091	247.65	0.000
		16	-0.001	0.084	247.65	0.000
		17	0.007	0.060	247.65	0.000
		18	0.034	0.114	247.80	0.000
		19	0.069	0.012	248.42	0.000
		20	0.090	-0.030	249.50	0.000
		21	0.095	-0.001	250.72	0.000
		22	0.098	0.041	252.02	0.000
		23	0.087	-0.073	253.06	0.000
		24	0.074	-0.046	253.81	0.000
		25	0.037	-0.151	254.01	0.000
		26	-0.001	0.027	254.01	0.000
		27	-0.028	-0.036	254.12	0.000
		28	-0.060	-0.109	254.64	0.000
		29	-0.093	-0.023	255.93	0.000
		30	-0.132	-0.050	258.54	0.000

3.1.4 YIELDS Correlogram (30 lags, roughly one third of 105 observations)

Date: 03/19/07 Time: 18:29
Sample: 1998M04 2006M12
Included observations: 105

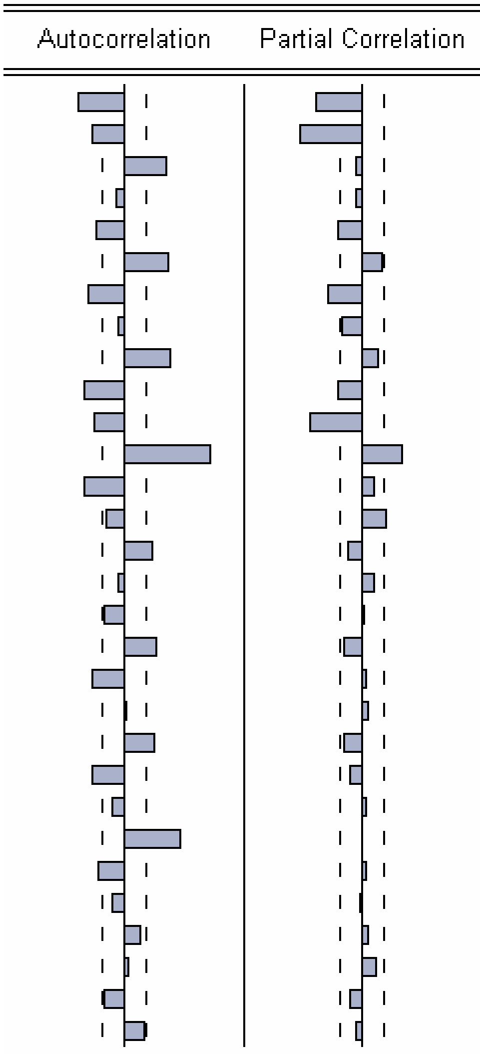


Lag	AC	PAC	Q-Stat	Prob
1	0.867	0.867	81.291	0.000
2	0.758	0.023	143.97	0.000
3	0.655	-0.032	191.16	0.000
4	0.597	0.129	230.84	0.000
5	0.581	0.158	268.71	0.000
6	0.602	0.184	309.79	0.000
7	0.555	-0.202	345.09	0.000
8	0.520	0.051	376.38	0.000
9	0.414	-0.252	396.41	0.000
10	0.340	0.032	410.11	0.000
11	0.280	-0.046	419.45	0.000
12	0.250	-0.020	427.00	0.000
13	0.237	0.069	433.85	0.000
14	0.257	0.097	442.03	0.000
15	0.223	-0.046	448.23	0.000
16	0.198	0.005	453.18	0.000
17	0.162	0.066	456.54	0.000
18	0.167	0.133	460.13	0.000
19	0.151	-0.113	463.12	0.000
20	0.143	-0.084	465.81	0.000
21	0.131	0.044	468.11	0.000
22	0.105	-0.135	469.61	0.000
23	0.072	0.020	470.32	0.000
24	0.053	-0.082	470.72	0.000
25	0.015	-0.057	470.75	0.000
26	-0.016	-0.076	470.79	0.000
27	-0.039	0.046	471.01	0.000
28	-0.067	-0.033	471.66	0.000
29	-0.091	-0.023	472.88	0.000
30	-0.111	0.054	474.72	0.000

3.2 Correlograms – First Differences

3.2.1 ΔM2CDs Correlogram (30 lags, roughly one third of 105 observations)

Date: 04/21/07 Time: 10:36
Sample: 1998M04 2006M12
Included observations: 104



Lag	AC	PAC	Q-Stat	Prob
1	-0.405	-0.405	17.515	0.000
2	-0.286	-0.538	26.383	0.000
3	0.363	-0.055	40.773	0.000
4	-0.081	-0.051	41.490	0.000
5	-0.250	-0.221	48.452	0.000
6	0.383	0.180	64.932	0.000
7	-0.313	-0.294	76.064	0.000
8	-0.055	-0.166	76.412	0.000
9	0.399	0.132	94.932	0.000
10	-0.338	-0.199	108.36	0.000
11	-0.262	-0.459	116.48	0.000
12	0.739	0.357	181.95	0.000
13	-0.352	0.100	196.98	0.000
14	-0.161	0.205	200.17	0.000
15	0.242	-0.128	207.44	0.000
16	-0.049	0.113	207.74	0.000
17	-0.180	0.020	211.83	0.000
18	0.284	-0.158	222.17	0.000
19	-0.271	0.038	231.66	0.000
20	0.012	0.048	231.68	0.000
21	0.264	-0.152	240.90	0.000
22	-0.283	-0.110	251.70	0.000
23	-0.112	0.031	253.40	0.000
24	0.478	-0.005	284.92	0.000
25	-0.234	0.037	292.54	0.000
26	-0.108	-0.021	294.17	0.000
27	0.145	0.053	297.18	0.000
28	0.029	0.116	297.30	0.000
29	-0.176	-0.105	301.85	0.000
30	0.177	-0.041	306.54	0.000

3.2.2 ΔCABS Correlogram (30 lags, roughly one third of 105 observations)

Date: 04/21/07 Time: 10:37
Sample: 1998M04 2006M12
Included observations: 104

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.404	-0.404	17.497	0.000
		2	-0.007	-0.204	17.502	0.000
		3	0.265	0.223	25.165	0.000
		4	-0.095	0.147	26.149	0.000
		5	-0.130	-0.124	28.041	0.000
		6	0.237	0.069	34.363	0.000
		7	-0.142	-0.020	36.640	0.000
		8	-0.059	-0.068	37.039	0.000
		9	0.095	-0.048	38.079	0.000
		10	-0.022	0.029	38.138	0.000
		11	-0.162	-0.116	41.234	0.000
		12	0.320	0.221	53.473	0.000
		13	-0.159	0.071	56.539	0.000
		14	-0.046	-0.028	56.798	0.000
		15	0.141	-0.036	59.266	0.000
		16	-0.043	0.005	59.495	0.000
		17	-0.156	-0.101	62.563	0.000
		18	0.263	0.091	71.446	0.000
		19	-0.127	0.049	73.538	0.000
		20	-0.094	-0.053	74.706	0.000
		21	0.162	0.017	78.210	0.000
		22	-0.062	0.000	78.721	0.000
		23	-0.131	-0.047	81.063	0.000
		24	0.273	0.096	91.334	0.000
		25	-0.035	0.192	91.508	0.000
		26	-0.199	-0.108	97.111	0.000
		27	0.246	0.004	105.75	0.000
		28	-0.100	-0.070	107.20	0.000
		29	-0.094	0.019	108.50	0.000
		30	0.138	-0.060	111.33	0.000

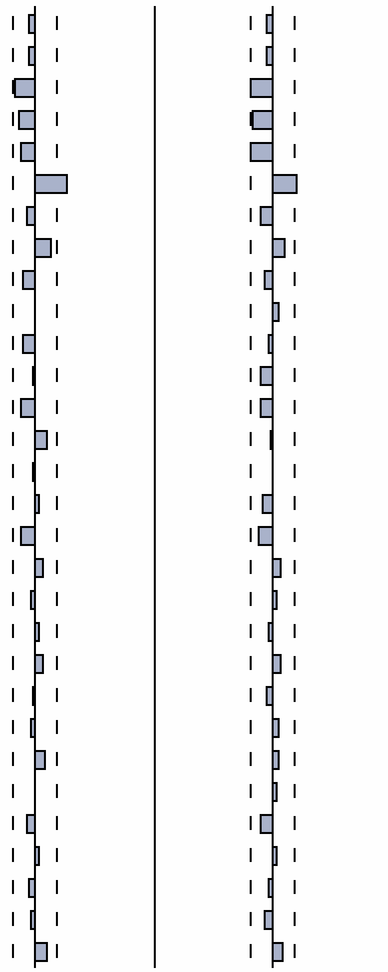
3.2.3 ΔRATES Correlogram (30 lags, roughly one third of 105 observations)

Date: 04/29/07 Time: 16:46
Sample: 1998M04 2006M12
Included observations: 104

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.309	0.309	10.234	0.001
		2	-0.123	-0.242	11.867	0.003
		3	-0.260	-0.162	19.222	0.000
		4	-0.259	-0.171	26.616	0.000
		5	-0.060	0.010	27.012	0.000
		6	0.109	0.029	28.343	0.000
		7	0.090	-0.043	29.261	0.000
		8	0.033	-0.010	29.383	0.000
		9	-0.075	-0.074	30.039	0.000
		10	-0.035	0.052	30.181	0.001
		11	0.000	-0.018	30.181	0.001
		12	-0.107	-0.161	31.548	0.002
		13	-0.097	-0.059	32.680	0.002
		14	-0.015	-0.008	32.707	0.003
		15	-0.014	-0.075	32.731	0.005
		16	-0.052	-0.139	33.068	0.007
		17	-0.055	-0.087	33.455	0.010
		18	-0.012	-0.021	33.473	0.015
		19	0.028	-0.026	33.578	0.021
		20	0.077	0.008	34.347	0.024
		21	0.016	-0.095	34.383	0.033
		22	0.033	0.057	34.528	0.043
		23	0.014	0.013	34.555	0.058
		24	0.105	0.131	36.078	0.054
		25	0.007	-0.121	36.086	0.070
		26	-0.042	0.002	36.334	0.086
		27	0.025	0.099	36.424	0.106
		28	-0.021	-0.069	36.487	0.131
		29	-0.017	-0.031	36.532	0.159
		30	0.051	0.012	36.925	0.179

3.2.4 ΔYIELDS Correlogram (30 lags, roughly one third of 105 observations)

Date: 04/21/07 Time: 10:38
Sample: 1998M04 2006M12
Included observations: 104



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.052	-0.052	0.2872	0.592
		2	-0.044	-0.046	0.4932	0.781
		3	-0.177	-0.183	3.9089	0.271
		4	-0.137	-0.166	5.9635	0.202
		5	-0.128	-0.181	7.7788	0.169
		6	0.277	0.214	16.381	0.012
		7	-0.059	-0.104	16.782	0.019
		8	0.140	0.101	19.048	0.015
		9	-0.113	-0.081	20.526	0.015
		10	0.002	0.047	20.527	0.025
		11	-0.100	-0.038	21.706	0.027
		12	-0.021	-0.111	21.757	0.040
		13	-0.124	-0.112	23.626	0.035
		14	0.113	-0.014	25.188	0.033
		15	-0.009	0.005	25.197	0.047
		16	0.025	-0.090	25.275	0.065
		17	-0.116	-0.124	26.973	0.058
		18	0.073	0.061	27.655	0.067
		19	-0.031	0.030	27.779	0.088
		20	0.039	-0.034	27.978	0.110
		21	0.065	0.074	28.540	0.125
		22	-0.024	-0.054	28.616	0.156
		23	-0.041	0.050	28.840	0.186
		24	0.086	0.042	29.866	0.189
		25	-0.001	0.034	29.867	0.229
		26	-0.059	-0.105	30.353	0.253
		27	0.034	0.037	30.520	0.291
		28	-0.045	-0.025	30.819	0.325
		29	-0.030	-0.077	30.952	0.368
		30	0.108	0.083	32.681	0.337

APPENDIX 4 – UNIT ROOT TESTS – DATA LEVELS

4.1 M2CDS

4.1.1 Log(M2CDS) Augmented Dickey-Fuller Test – **Constant**

Null Hypothesis: LOG(M2CDS) has a unit root
Exogenous: Constant
Lag Length: 12 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.806998	0.0612
Test critical values:	1% level	-3.503049	
	5% level	-2.893230	
	10% level	-2.583740	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOG(M2CDS))
Method: Least Squares
Date: 04/21/07 Time: 21:00
Sample (adjusted): 1999M05 2006M12

4.1.2 Log(M2CDS) Augmented Dickey-Fuller Test – **Constant and Trend**

Null Hypothesis: LOG(M2CDS) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 12 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.604492	0.9994
Test critical values:	1% level	-4.060874	
	5% level	-3.459397	
	10% level	-3.155786	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOG(M2CDS))
Method: Least Squares
Date: 04/21/07 Time: 21:11
Sample (adjusted): 1999M05 2006M12

4.2 CABS

4.2.1 Log(CABS) Augmented Dickey-Fuller Test – **Constant**

Null Hypothesis: LOG(CABS) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.722702	0.4168
Test critical values:	1% level	-3.496346	
	5% level	-2.890327	
	10% level	-2.582196	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOG(CABS))
Method: Least Squares
Date: 04/21/07 Time: 20:59
Sample (adjusted): 1998M08 2006M12

4.2.2 Log(CABS) Augmented Dickey-Fuller Test – **Constant and Trend**

Null Hypothesis: LOG(CABS) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 3 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.856365	0.9561
Test critical values:	1% level	-4.051450	
	5% level	-3.454919	
	10% level	-3.153171	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOG(CABS))
Method: Least Squares
Date: 04/21/07 Time: 20:59
Sample (adjusted): 1998M08 2006M12

4.3 RATES

4.3.1 RATES Augmented Dickey-Fuller Test – **Constant**

Null Hypothesis: RATES has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.632653	0.0066
Test critical values:	1% level	-3.495021	
	5% level	-2.889753	
	10% level	-2.581890	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RATES)
Method: Least Squares
Date: 04/29/07 Time: 16:49
Sample (adjusted): 1998M06 2006M12

4.3.2 RATES Augmented Dickey-Fuller Test – **Constant and Trend**

Null Hypothesis: RATES has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.610928	0.0337
Test critical values:	1% level	-4.049586	
	5% level	-3.454032	
	10% level	-3.152652	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RATES)
Method: Least Squares
Date: 04/29/07 Time: 16:50
Sample (adjusted): 1998M06 2006M12

4.4 YIELDS

4.4.1 YIELDS Augmented Dickey-Fuller Test – **Constant**

Null Hypothesis: YIELDS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.739468	0.0709
Test critical values:	1% level	-3.494378	
	5% level	-2.889474	
	10% level	-2.581741	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(YIELDS)
Method: Least Squares
Date: 04/21/07 Time: 20:54
Sample (adjusted): 1998M05 2006M12

4.4.2 YIELDS Augmented Dickey-Fuller Test – **Constant and Trend**

Null Hypothesis: YIELDS has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.638314	0.2646
Test critical values:	1% level	-4.048682	
	5% level	-3.453601	
	10% level	-3.152400	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(YIELDS)
Method: Least Squares
Date: 04/21/07 Time: 20:55
Sample (adjusted): 1998M05 2006M12

APPENDIX 5 – UNIT ROOT TESTS – 1ST DIFFERENCES

5.1 ΔM2CDS – Difference-Stationary Process (DSP) Testing

5.1.1 ΔLog(M2CDS) Augmented Dickey-Fuller Test – **Constant**

Null Hypothesis: D(LOG(M2CDS)) has a unit root
Exogenous: Constant
Lag Length: 11 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.454217	0.0115
Test critical values:	1% level	-3.503049	
	5% level	-2.893230	
	10% level	-2.583740	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOG(M2CDS),2)
Method: Least Squares
Date: 04/21/07 Time: 21:08
Sample (adjusted): 1999M05 2006M12

5.1.2 ΔLog (M2CDS) Augmented Dickey-Fuller Test – **Constant and Trend**

Null Hypothesis: D(LOG(M2CDS)) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 11 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.661581	0.0015
Test critical values:	1% level	-4.060874	
	5% level	-3.459397	
	10% level	-3.155786	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOG(M2CDS),2)
Method: Least Squares
Date: 04/21/07 Time: 21:09
Sample (adjusted): 1999M05 2006M12

5.2 ΔCABS – Difference-Stationary Process (DSP) Testing

5.2.1 ΔLog (CABS) Augmented Dickey-Fuller Test – **Constant**

Null Hypothesis: D(LOG(CABS)) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.630479	0.0000
Test critical values:	1% level	-3.496346	
	5% level	-2.890327	
	10% level	-2.582196	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOG(CABS),2)
Method: Least Squares
Date: 04/21/07 Time: 21:14
Sample (adjusted): 1998M08 2006M12

5.2.2 ΔLog (CABS) Augmented Dickey-Fuller Test – **Constant and Trend**

Null Hypothesis: D(LOG(CABS)) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.857139	0.0000
Test critical values:	1% level	-4.051450	
	5% level	-3.454919	
	10% level	-3.153171	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOG(CABS),2)
Method: Least Squares
Date: 04/21/07 Time: 21:14
Sample (adjusted): 1998M08 2006M12

5.3 ΔRATES – Difference-Stationary Process (DSP) Testing

5.3.1 Δ(RATES) Augmented Dickey-Fuller Test – **Constant**

Null Hypothesis: D(RATES) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.371140	0.0000
Test critical values:	1% level	-3.495021	
	5% level	-2.889753	
	10% level	-2.581890	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RATES,2)
Method: Least Squares
Date: 04/29/07 Time: 16:51
Sample (adjusted): 1998M06 2006M12

5.3.2 Δ(RATES) Augmented Dickey-Fuller Test – **Constant and Trend**

Null Hypothesis: D(RATES) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.334229	0.0000
Test critical values:	1% level	-4.049586	
	5% level	-3.454032	
	10% level	-3.152652	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RATES,2)
Method: Least Squares
Date: 04/29/07 Time: 16:52
Sample (adjusted): 1998M06 2006M12

5.4 ΔYIELDS – Difference-Stationary Process (DSP) Testing

5.4.1 Δ(YIELDS) Augmented Dickey-Fuller Test – **Constant**

Null Hypothesis: D(YIELDS) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.65325	0.0000
Test critical values:	1% level	-3.495021	
	5% level	-2.889753	
	10% level	-2.581890	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(YIELDS,2)
Method: Least Squares
Date: 04/21/07 Time: 21:15
Sample (adjusted): 1998M06 2006M12

5.4.2 Δ(YIELDS) Augmented Dickey-Fuller Test – **Constant and Trend**

Null Hypothesis: D(YIELDS) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.63167	0.0000
Test critical values:	1% level	-4.049586	
	5% level	-3.454032	
	10% level	-3.152652	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(YIELDS,2)
Method: Least Squares
Date: 04/21/07 Time: 21:16
Sample (adjusted): 1998M06 2006M12

APPENDIX 6 – TREND-STATIONARY PROCESS TESTING

6 TSP Trend-Stationary Process Testing: Regressing Absolute Levels of the Dependant Variable against a Time Trend ($Y_t = \beta_1 + \beta_2 t + u_t$)

6.1 M2CDS

Dependent Variable: LOG(M2CDS)
Method: Least Squares
Date: 03/21/07 Time: 12:52
Sample: 1998M04 2006M12
Included observations: 105

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	15.61320	0.002197	7107.275	0.0000
@TREND	0.001875	3.65E-05	51.38516	0.0000

R-squared	0.962456	Mean dependent var	15.71073
Adjusted R-squared	0.962091	S.D. dependent var	0.058221
S.E. of regression	0.011336	Akaike info criterion	-6.102855
Sum squared resid	0.013235	Schwarz criterion	-6.052304
Log likelihood	322.3999	F-statistic	2640.435
Durbin-Watson stat	1.031559	Prob(F-statistic)	0.000000

6.2 CABS

Dependent Variable: LOG(CABS)
Method: Least Squares
Date: 03/21/07 Time: 12:54
Sample: 1998M04 2006M12
Included observations: 105

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	10.69867	0.103163	103.7064	0.0000
@TREND	0.020796	0.001714	12.13285	0.0000

R-squared	0.588339	Mean dependent var	11.78005
Adjusted R-squared	0.584343	S.D. dependent var	0.825688
S.E. of regression	0.532333	Akaike info criterion	1.595770
Sum squared resid	29.18800	Schwarz criterion	1.646321
Log likelihood	-81.77791	F-statistic	147.2060
Durbin-Watson stat	0.366381	Prob(F-statistic)	0.000000

6.3 RATES

Dependent Variable: RATES
Method: Least Squares
Date: 04/29/07 Time: 16:55
Sample: 1998M04 2006M12
Included observations: 105

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.510530	0.060770	24.85663	0.0000
@TREND	-0.001083	0.001010	-1.072180	0.2861

R-squared	0.011038	Mean dependent var	1.454238
Adjusted R-squared	0.001436	S.D. dependent var	0.313804
S.E. of regression	0.313579	Akaike info criterion	0.537331
Sum squared resid	10.12815	Schwarz criterion	0.587883
Log likelihood	-26.20988	F-statistic	1.149570
Durbin-Watson stat	0.237174	Prob(F-statistic)	0.286145

6.4 YIELDS

Dependent Variable: YIELDS
Method: Least Squares
Date: 04/29/07 Time: 16:54
Sample: 1998M04 2006M12
Included observations: 105

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.917148	0.058594	32.71935	0.0000
@TREND	-0.003924	0.000974	-4.030331	0.0001

R-squared	0.136222	Mean dependent var	1.713124
Adjusted R-squared	0.127836	S.D. dependent var	0.323751
S.E. of regression	0.302350	Akaike info criterion	0.464402
Sum squared resid	9.415811	Schwarz criterion	0.514954
Log likelihood	-22.38112	F-statistic	16.24357
Durbin-Watson stat	0.278367	Prob(F-statistic)	0.000107

APPENDIX 7 – COINTEGRATION TESTS

7.1 Engle-Granger (EG) Test

7.1.1 Residuals with respect to M2CDS versus CABS – Model (a)

Null Hypothesis: RESIDUALSM2CDS has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.592514	0.7894
Test critical values:	1% level	-4.049586	
	5% level	-3.454032	
	10% level	-3.152652	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESIDUALSM2CDS)
Method: Least Squares
Date: 04/21/07 Time: 22:17
Sample (adjusted): 1998M06 2006M12

7.1.2 Residuals with respect to RATES versus CABS – Model (b)

Null Hypothesis: RESIDUALSRATES has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.912537	0.1629
Test critical values:	1% level	-4.048682	
	5% level	-3.453601	
	10% level	-3.152400	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESIDUALSRATES)
Method: Least Squares
Date: 04/29/07 Time: 17:03
Sample (adjusted): 1998M05 2006M12
Included observations: 104 after adjustments

7.1.3 Residuals with respect to YIELDS versus CABS – Model (c)

Null Hypothesis: RESIDUALSYIELDS has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.387923	0.0586
Test critical values:	1% level	-4.048682	
	5% level	-3.453601	
	10% level	-3.152400	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESIDUALSYIELDS)
Method: Least Squares
Date: 04/21/07 Time: 22:18
Sample (adjusted): 1998M05 2006M12

7.2 Cointegrating Regression Durbin-Watson (CRDW) Test

7.2.1 M2CDS versus Cabs – Model (a)

Dependent Variable: LOG(M2CDS)
Method: Least Squares
Date: 03/11/07 Time: 16:00
Sample: 1998M04 2006M12
Included observations: 105

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	15.02883	0.046849	320.7947	0.0000
LOG(CABS)	0.057886	0.003967	14.59067	0.0000

R-squared	0.673935	Mean dependent var	15.71073
Adjusted R-squared	0.670769	S.D. dependent var	0.058221
S.E. of regression	0.033406	Akaike info criterion	-3.941276
Sum squared resid	0.114947	Schwarz criterion	-3.890724
Log likelihood	208.9170	F-statistic	212.8876
Durbin-Watson stat	0.284538	Prob(F-statistic)	0.000000

7.2.2 RATES versus CABS – Model (b)

Dependent Variable: RATES
Method: Least Squares
Date: 04/29/07 Time: 17:05
Sample: 1998M04 2006M12
Included observations: 105

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.936126	0.417280	7.036344	0.0000
LOG(CABS)	-0.125796	0.035337	-3.559933	0.0006

R-squared	0.109560	Mean dependent var	1.454238
Adjusted R-squared	0.100915	S.D. dependent var	0.313804
S.E. of regression	0.297549	Akaike info criterion	0.432391
Sum squared resid	9.119170	Schwarz criterion	0.482942
Log likelihood	-20.70051	F-statistic	12.67312
Durbin-Watson stat	0.276828	Prob(F-statistic)	0.000563

7.2.3 YIELDS versus CABS – Model (c)

Dependent Variable: YIELDS
Method: Least Squares
Date: 04/21/07 Time: 22:23
Sample: 1998M04 2006M12
Included observations: 105

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.125449	0.389059	10.60366	0.0000
LOG(CABS)	-0.204781	0.032947	-6.215478	0.0000

R-squared	0.272764	Mean dependent var	1.713124
Adjusted R-squared	0.265704	S.D. dependent var	0.323751
S.E. of regression	0.277426	Akaike info criterion	0.292337
Sum squared resid	7.927400	Schwarz criterion	0.342889
Log likelihood	-13.34770	F-statistic	38.63217
Durbin-Watson stat	0.398165	Prob(F-statistic)	0.000000

APPENDIX 8 – MODEL TESTING

EQUATION 3.1.1

8.1 Basic Results

$$\Delta Log\ (M2CDs)_t = \beta_1 + \beta_2 \Delta Log\ (CABS)_t + u_t$$

Dependent Variable: DLOG(M2CDS)
Method: Least Squares
Date: 03/28/07 Time: 23:14
Sample (adjusted): 1998M05 2006M12
Included observations: 104 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001834	0.001048	1.749587	0.0832
DLOG(CABS)	0.013703	0.003270	4.190789	0.0001

R-squared	0.146891	Mean dependent var	0.001961
Adjusted R-squared	0.138527	S.D. dependent var	0.011513
S.E. of regression	0.010686	Akaike info criterion	-6.220773
Sum squared resid	0.011647	Schwarz criterion	-6.169919
Log likelihood	325.4802	F-statistic	17.56271
Durbin-Watson stat	2.763746	Prob(F-statistic)	0.000059

Of particular importance is the high Durbin Watson statistic (which is greater than the critical 2.31 and 2.43 values). The Serial Correlation Test with respect to the above regression is given below, with the result illustrating a significant presence of serial correlation.

8.2 Serial Correlation Test on the above regression

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	17.26030	Prob. F(12,90)	0.000000
Obs*R-squared	72.49795	Prob. Chi-Square(12)	0.000000

8.3 Correlogram test on regression 3.1.1

The correlogram test below gives a good impression of the nature of the serial correlation exhibited by the regression and confirmed in the Serial Correlation LM test shown above. The information given by the relevant spikes at various lags (particularly at Lag 1 and Lag 12) were used as the basis for including AR, MA and SAR terms in the model as part of a trial and error process which yielded the final regression model.

Date: 04/23/07 Time: 16:06
Sample: 1998M05 2006M12
Included observations: 104

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.394	-0.394	16.606	0.000
		2	-0.173	-0.389	19.849	0.000
		3	0.161	-0.121	22.679	0.000
		4	-0.025	-0.079	22.749	0.000
		5	-0.194	-0.271	26.937	0.000
		6	0.351	0.179	40.833	0.000
		7	-0.309	-0.224	51.656	0.000
		8	0.039	-0.061	51.832	0.000
		9	0.206	0.083	56.766	0.000
		10	-0.265	-0.244	65.007	0.000
		11	-0.161	-0.377	68.075	0.000
		12	0.629	0.346	115.55	0.000
		13	-0.330	0.121	128.78	0.000
		14	-0.077	0.038	129.50	0.000
		15	0.089	-0.112	130.48	0.000
		16	-0.002	0.102	130.48	0.000
		17	-0.100	0.015	131.76	0.000
		18	0.232	-0.093	138.65	0.000
		19	-0.300	-0.049	150.35	0.000
		20	0.151	0.088	153.36	0.000
		21	0.082	-0.086	154.26	0.000
		22	-0.216	-0.087	160.53	0.000
		23	-0.037	0.003	160.71	0.000
		24	0.393	0.032	181.96	0.000
		25	-0.219	0.057	188.66	0.000
		26	0.020	0.152	188.71	0.000
		27	-0.021	0.069	188.77	0.000
		28	0.068	0.177	189.44	0.000
		29	-0.130	-0.130	191.91	0.000
		30	0.130	-0.078	194.43	0.000

APPENDIX 9 – MODEL TESTING

EQUATION 3.1.2

9.1 Basic Results

$$\Delta\ (RATES)_t = \alpha_1 + \alpha_2 \Delta Log\ (CABS)_t + u_t$$

Dependent Variable: D(RATES)
Method: Least Squares
Date: 04/29/07 Time: 17:07
Sample (adjusted): 1998M05 2006M12
Included observations: 104 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.001973	0.015044	-0.131161	0.8959
DLOG(CABS)	-0.017373	0.046925	-0.370223	0.7120

R-squared	0.001342	Mean dependent var	-0.002135
Adjusted R-squared	-0.008449	S.D. dependent var	0.152711
S.E. of regression	0.153354	Akaike info criterion	-0.893086
Sum squared resid	2.398795	Schwarz criterion	-0.842232
Log likelihood	48.44047	F-statistic	0.137065
Durbin-Watson stat	1.355045	Prob(F-statistic)	0.711984

The initial regression results presented significant issues. The explanatory variable was found to be insignificant, leading to an extremely low R^2 (this is to be expected in a single variable regression). The results also showed significant serial correlation confirmed though the serial correlation LM test, given below.

9.2 Serial Correlation Test on the above regression

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.343811	Prob. F(12,90)	0.011504
Obs*R-squared	24.76239	Prob. Chi-Square(12)	0.015990

9.3 Correlogram test on regression 3.1.2

Correlogram analysis of the above equation illustrates significant spikes at Lags 1, 2, 3, and 4. There is also a considerable spike at Lag 12. A trial and error method using both correlogram analysis and serial correlation LM tests was again utilised in order to reformulate the economic model through the inclusion of the relevant MA, AR and SAR terms.

Date: 04/29/07 Time: 17:11
Sample: 1998M05 2006M12
Included observations: 104

	AC	PAC	Q-Stat	Prob
1	0.313	0.313	10.480	0.001
2	-0.127	-0.249	12.216	0.002
3	-0.261	-0.158	19.671	0.000
4	-0.258	-0.170	27.016	0.000
5	-0.057	0.012	27.383	0.000
6	0.108	0.024	28.692	0.000
7	0.088	-0.043	29.579	0.000
8	0.032	-0.010	29.694	0.000
9	-0.077	-0.078	30.390	0.000
10	-0.037	0.051	30.551	0.001
11	0.005	-0.013	30.555	0.001
12	-0.108	-0.168	31.954	0.001
13	-0.094	-0.050	33.026	0.002
14	-0.014	-0.012	33.050	0.003
15	-0.027	-0.091	33.141	0.004
16	-0.053	-0.130	33.493	0.006
17	-0.053	-0.091	33.853	0.009
18	-0.018	-0.034	33.892	0.013
19	0.037	-0.019	34.066	0.018
20	0.079	0.004	34.892	0.021
21	0.010	-0.103	34.906	0.029
22	0.035	0.062	35.070	0.038
23	0.019	0.016	35.121	0.051
24	0.105	0.123	36.632	0.048
25	0.009	-0.120	36.642	0.062
26	-0.043	0.007	36.899	0.076
27	0.025	0.094	36.989	0.095
28	-0.021	-0.071	37.051	0.118
29	-0.016	-0.025	37.087	0.144
30	0.047	0.000	37.411	0.165

APPENDIX 10 – MODEL TESTING

EQUATION 3.1.3

10.1 Basic Results

$$\Delta\ (YIELDS)_t = \eta_1 + \eta_2 \Delta Log\ (CABS)_t + u_t$$

Dependent Variable: D(YIELDS)
Method: Least Squares
Date: 04/23/07 Time: 16:44
Sample (adjusted): 1998M05 2006M12
Included observations: 104 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.002552	0.015712	-0.162409	0.8713
DLOG(CABS)	0.020054	0.049008	0.409201	0.6833

R-squared	0.001639	Mean dependent var	-0.002365
Adjusted R-squared	-0.008149	S.D. dependent var	0.159514
S.E. of regression	0.160162	Akaike info criterion	-0.806215
Sum squared resid	2.616499	Schwarz criterion	-0.755362
Log likelihood	43.92319	F-statistic	0.167446
Durbin-Watson stat	2.084354	Prob(F-statistic)	0.683250

Once again there are severe limitations to the validity of the results, as exhibited by the insignificant explanatory variable. This in turn leads to the very low R^2 (inevitable given a single regression model). Serial correlation was found to be present following a Serial Correlation LM test, given below.

10.2 Serial Correlation Test on the above regression

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.571953	Prob. F(12,90)	0.114173
Obs*R-squared	18.02072	Prob. Chi-Square(12)	0.115063

10.3 Correlogram test on regression 3.1.3

The correlogram below shows a number of significant spikes, particularly at Lags 3, 4, 5, and 6. Correlogram analysis was used for remodelling the economic equation, inserting the relevant MA, AR and SAR terms in order to reduce as much as possible the AC and PAC spikes.

Date: 04/23/07 Time: 16:49
Sample: 1998M05 2006M12
Included observations: 104

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.052	-0.052	0.2863	0.593
		2	-0.037	-0.040	0.4329	0.805
		3	-0.185	-0.189	4.1499	0.246
		4	-0.138	-0.168	6.2618	0.180
		5	-0.119	-0.170	7.8394	0.165
		6	0.265	0.202	15.717	0.015
		7	-0.050	-0.095	16.003	0.025
		8	0.144	0.101	18.400	0.018
		9	-0.123	-0.086	20.159	0.017
		10	0.015	0.060	20.184	0.028
		11	-0.097	-0.036	21.291	0.030
		12	-0.032	-0.114	21.417	0.045
		13	-0.119	-0.113	23.127	0.040
		14	0.112	-0.007	24.653	0.038
		15	-0.010	0.007	24.666	0.055
		16	0.034	-0.087	24.808	0.073
		17	-0.113	-0.118	26.424	0.067
		18	0.070	0.063	27.052	0.078
		19	-0.034	0.031	27.199	0.100
		20	0.044	-0.023	27.450	0.123
		21	0.058	0.066	27.903	0.143
		22	-0.017	-0.041	27.940	0.178
		23	-0.043	0.044	28.196	0.208
		24	0.082	0.043	29.125	0.215
		25	-0.003	0.031	29.126	0.259
		26	-0.052	-0.104	29.508	0.289
		27	0.027	0.040	29.611	0.332
		28	-0.043	-0.031	29.875	0.369
		29	-0.028	-0.070	29.993	0.414
		30	0.105	0.080	31.643	0.384

APPENDIX 11 – FINAL RESULTS

ARIMA EQUATION 3.1.1

11.1 $\Delta \text{Log}(\text{M2CDs})_t = \beta_1 + \beta_2 \Delta \text{Log}(\text{CABS}) + \text{ARMA terms} + u_t$

Dependent Variable: DLOG(M2CDS)
Method: Least Squares
Date: 04/20/07 Time: 17:31
Sample (adjusted): 1999M06 2006M12
Included observations: 91 after adjustments
Convergence achieved after 31 iterations
Backcast: 1998M06 1999M05

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001760	0.000572	3.079166	0.0028
DLOG(CABS)	0.003848	0.000876	4.393443	0.0000
AR(7)	-0.209456	0.062029	-3.376772	0.0011
AR(12)	0.762363	0.057709	13.21053	0.0000
SAR(1)	-0.553488	0.091999	-6.016221	0.0000
MA(2)	-0.702358	0.051324	-13.68474	0.0000
MA(9)	0.385914	0.045836	8.419486	0.0000
MA(12)	0.133507	0.040840	3.269035	0.0016

R-squared	0.856712	Mean dependent var	0.001833
Adjusted R-squared	0.844627	S.D. dependent var	0.011677
S.E. of regression	0.004603	Akaike info criterion	-7.840486
Sum squared resid	0.001758	Schwarz criterion	-7.619751
Log likelihood	364.7421	F-statistic	70.89303
Durbin-Watson stat	2.014702	Prob(F-statistic)	0.000000

Inverted AR Roots	.96	.87+.49i	.87-.49i	.47-.85i
	.47+.85i	.02+.98i	.02-.98i	-.51-.85i
	-.51+.85i	-.55	-.83-.49i	-.83+.49i
	-1.00			
Inverted MA Roots	.97-.24i	.97+.24i	.50+.61i	.50-.61i
	.30+.64i	.30-.64i	-.20+.85i	-.20-.85i
	-.69	-.73-.55i	-.73+.55i	-.99

11.2 Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.382803	Prob. F(12,71)	0.965573
Obs*R-squared	5.528545	Prob. Chi-Square(12)	0.937962

11.3 Correlogram of ARIMA Equation 3.1.1

$$\Delta \text{Log}(\text{M2CDs})_t = \beta_1 + \beta_2 \Delta \text{Log}(\text{CABS}) + \text{ARMA terms} + u_t$$

Date: 04/23/07 Time: 17:58
Sample: 1999M06 2006M12
Included observations: 91
Q-statistic probabilities adjusted for 6 ARMA term(s)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.016	-0.016	0.0244	
		2	0.018	0.018	0.0558	
		3	0.127	0.127	1.5960	
		4	0.021	0.026	1.6396	
		5	0.028	0.024	1.7160	
		6	0.102	0.088	2.7593	
		7	0.011	0.009	2.7723	0.096
		8	-0.078	-0.090	3.3874	0.184
		9	-0.006	-0.036	3.3917	0.335
		10	-0.008	-0.014	3.3976	0.494
		11	-0.143	-0.134	5.5660	0.351
		12	-0.049	-0.060	5.8228	0.443
		13	-0.042	-0.036	6.0167	0.538
		14	-0.033	0.016	6.1375	0.632
		15	-0.058	-0.033	6.5073	0.688
		16	0.058	0.079	6.8919	0.736
		17	0.015	0.059	6.9167	0.806
		18	-0.030	-0.001	7.0187	0.856
		19	0.028	0.004	7.1108	0.896
		20	0.160	0.156	10.150	0.751
		21	0.017	0.026	10.186	0.808
		22	-0.139	-0.202	12.539	0.706
		23	0.114	0.041	14.170	0.655
		24	-0.063	-0.073	14.664	0.685
		25	-0.070	-0.084	15.295	0.704
		26	0.072	0.005	15.976	0.718
		27	-0.136	-0.106	18.434	0.621
		28	-0.028	0.043	18.536	0.674
		29	-0.136	-0.155	21.068	0.577
		30	-0.099	-0.082	22.436	0.553

As can be seen from the above correlogram, the inclusion of the ARMA terms in the above equation has removed most of the AC and PAC spikes exhibited by the original regression.

APPENDIX 12 – FINAL RESULTS

ARIMA EQUATION 3.1.2

12.1 $\Delta\,(\text{RATES})_t = \alpha_1 + \alpha_2 \Delta \text{Log(CABS)} + \text{ARMA terms} + u_t$

Dependent Variable: D(RATES)
Method: Least Squares
Date: 04/29/07 Time: 17:16
Sample (adjusted): 2001M05 2006M12
Included observations: 68 after adjustments
Convergence achieved after 23 iterations
Backcast: 2001M03 2001M04

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.012017	0.006252	1.922095	0.0593
DLOG(CABS)	-0.207863	0.044569	-4.663875	0.0000
AR(2)	0.659229	0.099116	6.651061	0.0000
AR(12)	-0.106643	0.090597	-1.177104	0.2437
SAR(1)	0.192434	0.118999	1.617104	0.1110
SAR(24)	0.250993	0.101696	2.468072	0.0164
MA(2)	-0.963624	0.031793	-30.30968	0.0000

R-squared	0.309089	Mean dependent var	0.004853
Adjusted R-squared	0.241131	S.D. dependent var	0.124806
S.E. of regression	0.108722	Akaike info criterion	-1.502795
Sum squared resid	0.721050	Schwarz criterion	-1.274316
Log likelihood	58.09502	F-statistic	4.548205
Durbin-Watson stat	1.950846	Prob(F-statistic)	0.000713

12.2 Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.528458	Prob. F(12,49)	0.885710
Obs*R-squared	7.700360	Prob. Chi-Square(12)	0.808086

12.3 Correlogram of ARIMA Equation 3.1.2

$$\Delta\,(\text{RATES})_t = \alpha_1 + \alpha_2 \Delta\text{Log(CABS)} + \text{ARMA terms} + u_t$$

Date: 04/29/07 Time: 19:46
Sample: 2001M05 2006M12
Included observations: 68
Q-statistic probabilities adjusted for 5 ARMA term(s)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.017	0.017	0.0200	
		2	0.032	0.031	0.0928	
		3	-0.061	-0.063	0.3689	
		4	0.000	0.001	0.3689	
		5	-0.074	-0.071	0.7856	
		6	-0.048	-0.050	0.9631	0.326
		7	-0.046	-0.040	1.1283	0.569
		8	0.132	0.129	2.5031	0.475
		9	-0.113	-0.124	3.5294	0.473
		10	0.051	0.041	3.7420	0.587
		11	0.025	0.039	3.7947	0.704
		12	-0.118	-0.153	4.9863	0.662
		13	-0.177	-0.161	7.6836	0.465
		14	-0.033	-0.016	7.7810	0.556
		15	-0.043	-0.050	7.9470	0.634
		16	0.089	0.056	8.6795	0.651
		17	-0.139	-0.132	10.476	0.574
		18	0.044	-0.021	10.661	0.639
		19	0.018	0.000	10.692	0.710
		20	-0.052	-0.064	10.965	0.755
		21	-0.015	-0.010	10.989	0.810
		22	-0.017	-0.053	11.018	0.856
		23	0.114	0.140	12.383	0.827
		24	0.092	0.051	13.305	0.823
		25	-0.129	-0.165	15.158	0.767
		26	-0.152	-0.252	17.790	0.662
		27	0.035	0.045	17.935	0.710
		28	-0.077	-0.048	18.636	0.722
		29	-0.008	-0.058	18.644	0.771
		30	0.101	0.091	19.917	0.751

The correlogram analysis shows significant improvements in the AC and PAC coefficients. Efforts to remove the PAC spike at Lag 26 resulted in a significant increase in the risk of serial correlation, and it was decided to retain the model as expressed above.

APPENDIX 13 – FINAL RESULTS

ARIMA EQUATION 3.1.3

13.1 $\Delta\ (\text{YIELDS})_t = \eta_1 + \eta_2 \Delta \text{Log(CABS)} + \text{ARMA terms} + u_t$

Dependent Variable: D(YIELDS)
Method: Least Squares
Date: 05/07/07 Time: 00:19
Sample (adjusted): 2001M07 2006M12
Included observations: 66 after adjustments
Convergence achieved after 29 iterations
Backcast: 2001M01 2001M06

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004739	0.001928	2.457439	0.0170
DLOG(CABS)	-0.211751	0.039083	-5.417941	0.0000
AR(4)	-0.332788	0.077998	-4.266597	0.0001
AR(5)	-0.204732	0.054768	-3.738169	0.0004
AR(6)	0.532283	0.092795	5.736145	0.0000
AR(26)	-0.224568	0.066420	-3.381018	0.0013
SAR(12)	-0.385609	0.123008	-3.134837	0.0027
MA(6)	-0.947039	0.028660	-33.04342	0.0000

R-squared	0.441693	Mean dependent var	0.008485
Adjusted R-squared	0.374311	S.D. dependent var	0.113256
S.E. of regression	0.089586	Akaike info criterion	-1.874019
Sum squared resid	0.465490	Schwarz criterion	-1.608606
Log likelihood	69.84262	F-statistic	6.555077
Durbin-Watson stat	2.256100	Prob(F-statistic)	0.000010

13.2 Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.399209	Prob. F(12,46)	0.956731
Obs*R-squared	5.557552	Prob. Chi-Square(12)	0.936725

13.3 Correlogram of ARIMA Equation 3.1.3

$$\Delta\,(\text{YIELDS})_t = \eta_1 + \eta_2 \Delta \text{Log(CABS)} + \text{ARMA terms} + u_t$$

Date: 05/07/07 Time: 00:23
Sample: 2001M07 2006M12
Included observations: 66
Q-statistic probabilities adjusted for 6 ARMA term(s)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.145	-0.145	1.4495	
		2	0.006	-0.016	1.4518	
		3	0.014	0.013	1.4655	
		4	0.190	0.198	4.0677	
		5	-0.091	-0.037	4.6809	
		6	-0.056	-0.079	4.9141	
		7	0.014	-0.017	4.9292	0.026
		8	0.002	-0.031	4.9295	0.085
		9	-0.131	-0.112	6.2767	0.099
		10	-0.022	-0.038	6.3150	0.177
		11	0.013	-0.001	6.3298	0.275
		12	0.001	0.014	6.3299	0.387
		13	-0.153	-0.116	8.3079	0.306
		14	-0.102	-0.163	9.2120	0.325
		15	-0.115	-0.199	10.376	0.321
		16	0.080	0.035	10.957	0.361
		17	-0.130	-0.067	12.511	0.326
		18	-0.059	-0.082	12.835	0.381
		19	0.085	0.073	13.532	0.408
		20	0.054	0.032	13.821	0.463
		21	0.035	0.074	13.945	0.530
		22	-0.156	-0.201	16.418	0.424
		23	0.192	0.039	20.268	0.261
		24	0.037	0.035	20.411	0.310
		25	-0.072	-0.057	20.975	0.338
		26	-0.009	-0.014	20.983	0.398
		27	0.101	-0.019	22.169	0.390
		28	-0.048	-0.092	22.444	0.434
		29	-0.038	-0.043	22.623	0.483
		30	0.188	0.166	27.046	0.302

The inclusion of ARMA terms has once again considerably improved the regression results, allowing for considerably smaller spikes in both the AC and PAC coefficients.